User's Manual

R-IN32M3 Series

User's Manual: TCP/IP stack

- R-IN32M3-EC
- R-IN32M3-CL

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Please refer to this manual about individual precaution.
When there is a mention unlike the text of this manual, a mention of the text takes first priority

1.Handling of Unused Pins

Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.

-The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2.Processing at Power-on

The state of the product is undefined at the moment when power is supplied.

-The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3.Prohibition of Access to Reserved Addresses

Access to reserved addresses is prohibited.

-The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4.Clock Signals

After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

-When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

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How to use this manual

1. Purpose and target readers

This manual is intended for users who wish to understand the functions of Industrial Ethernet network LSI "R-IN32M3-EC/CL" for designing application of it.

It is assumed that the reader of this manual has general knowledge in the fields of electrical engineering, logic circuits, and microcontrollers.

Particular attention should be paid to the precautionary notes when using the manual. These notes occur within the body of the text, at the end of each section, and in the Usage Notes section.

The revision history summarizes the locations of revisions and additions. It does not list all revisions. Refer to the text of the manual for details.
The mark "<R>" means the updated point in this revision. The mark "<R>" let users search for the updated point in this document.

Related Documents

The related documents indicated in this publication may include preliminary versions. However, preliminary versions are not marked as such. Please be understanding of this beforehand. In addition, because we make document at development, planning of each core, the related document may be the document for individual customers. Last four digits of document number(described as ****) indicate version information of each document. Please download the latest document from our web site and refer to it.

The document related to R-IN32M3 Series

Document name	Document number
R-IN32M3 Series Datasheet	R18DS0008EJ****
R-IN32M3-EC User's Manual	R18UZ0003EJ****
R-IN32M3-CL User's Manual	R18UZ0005EJ****
R-IN32M3 Series User's Manual Peripheral function	R18UZ0007EJ****
R-IN32M3 Series Programming Manual (Driver edition)	R18UZ0009EJ****
R-IN32M3 Series Programming Manual (OS edition)	R18UZ0011EJ****
R-IN32M3 Series User's Manual TCP/IP stack	This Manual

2. Notation of Numbers and Symbols

Weight in data notation: Left is high-order column, right is low-order column

Active low notation:

xxxZ (capital letter Z after pin name or signal name)

or xxx_N (capital letter _N after pin name or signal name)

or xxnx (pin name or signal name contains small letter n)

Note:

explanation of (Note) in the text

Caution:

Item deserving extra attention

Remark:

Supplementary explanation to the text

Numeric notation:

Binary ⋯ xxxx , xxxxB or n'bxxxx (n bits)

Decimal ⋯ xxxx

Hexadecimal ⋯ xxxxH or n'hxxxx (n bits)

Prefixes representing powers of 2 (address space, memory capacity):

K (kilo)⋯ $2^{10} = 1024$

M (mega)⋯ $2^{20} = 1024^2$

G (giga)⋯ $2^{30} = 1024^3$

Data Type:

Word ⋯ 32 bits

Halfword ⋯ 16 bits

Byte ⋯ 8 bits

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1. Overview

This document explains TCP/IP and UDP/IP protocol stacks for R-IN32M3 series.

Function summary and Application Programming Interface (API) and application samples of TCP/IP protocol stack provided by Renesas are described in this document.

There are 2 versions of TCP/IP stack; one is "Evaluation Edition" downloaded from Renesas WEB, the other one is "Commercial Edition" released to only user who have purchased R-IN32M3 device.

1.1 Features

TCP/IP stack is a compact stack optimized for R-IN32M3. This stack uses "uNet3" customized and produced by eForce Co., Ltd.

1.2 Key Functions

TCP/IP stack for R-IN32M3 has key functions as follows:

- IPv4, ARP, ICMP, IGMPv2, UDP, TCP protocol
- DHCP client, DNS client, FTP server, HTTP server
- TCP/IP configuration
- TCP fast retransmit and fast recovery
- IP reconstructure and fragmentation
- Multiple network interface

The difference between evaluation edition and commercial edition shows at table1.1:

Table 1.1 The difference between evaluation edition and commercial edition<R>

Function / Package	Commercial Edition	Evaluation Edition
Max socket number(TCP)	Depends on memory size	4
Max socket number(UDP)	Depends on memory size	4
IP reassemble	Yes	No
Multicast	Yes	No
TCP Keep-Alive	Yes	No
Protocol stack configurations (e.g. TCP tuning)	Yes	No
Provides source code of network application	Yes	No
Provides source code of network device driver	Yes	No
Provides source code of protocol stack	No	No

1.3 Development environment

The development environment of TCP/IP protocol stack is described here.

1.3.1 Development tools

Development tools is showed in Table 1.2.

Table 1.2 Development tools

Tool Chain	IDE	Compiler	Debugger	ICE
ARM	-	RealView Developer Suite V4.1 (ARM)	microVIEW-PLUS Ver.5.11PL3 (Yokogawa Digital Computer Corporation)	adviceLUNA 2.03-00 (Yokogawa Digital Computer Corporation)
GNU	-	Sourcery G++ Lite 2012.09-63 (Mentor Graphics)	microVIEW-PLUS Ver.5.11PL3 (Yokogawa Digital Computer Corporation)	adviceLUNA 2.03-00 (Yokogawa Digital Computer Corporation)
IAR	Embedded Workbench for ARM V6.60.1 (IAR Systems)	Embedded Workbench for ARM V6.60.1 (IAR Systems)	Embedded Workbench for ARM V6.60.1 (IAR Systems)	i-Jet JTAGjet-Trace-CM (IAR Systems)

1.3.2 Evaluation board

TCP/IP stack sample application behavior can be confirmed on “TS-R-IN32M3 evaluation board” made by TESSERA TECHNOLOGY INC.

Please get more detail from Renesas or TESSERA TECHNOLOGY INC. WEB site.

1.3.3 Development procedure

Standard development procedure is as follows:

1. Merge TCP/IP stack program and R-IN32M3 samplesoft which has driver/middleware.
2. Modify net_cfg.c to configure network parameter (IP address, socket definition) and how to call initialize routine.
3. Make the execution file by build (compile & link), after application program is created.

The relationship among files is showed at Fig. 1.1.

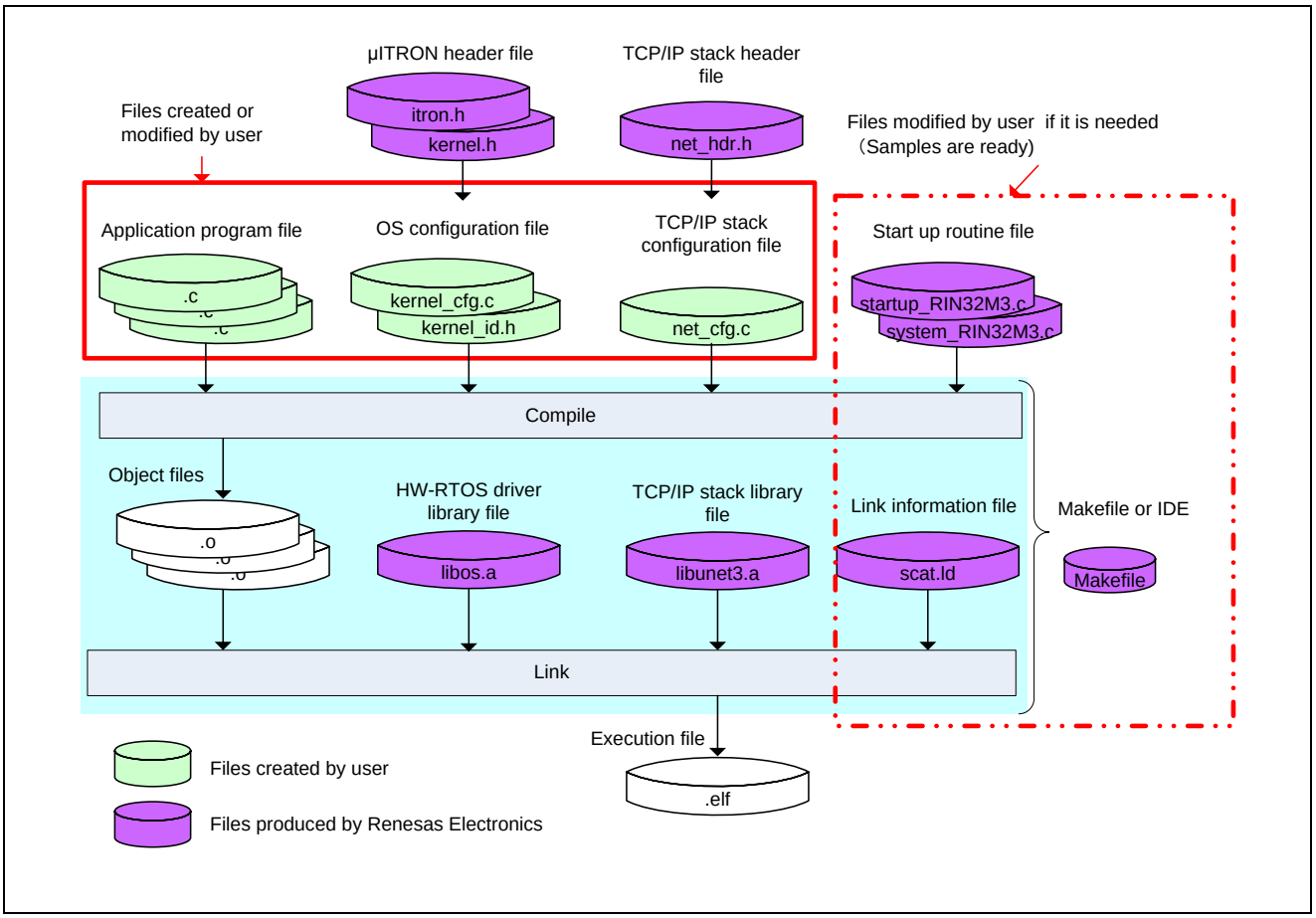


Fig. 1.1 The figure of relationship among files

2. Basic concepts of R-IN32M3 TCP/IP stack

2.1 Glossary

2.1.1 Protocol

Protocol is a set of rules that determines the method and the procedure of transmitting data between networks. R-IN32M3 TCP/IP stack adopts this protocol (=communication rule). These rules are called Request For Comments (abbreviation: RFC)", its specification is published.

2.1.2 Protocol stack

Choose a necessary protocol in order to implement functions on network, and a protocol stack is a prescribed hierarchy of software layers. The following figure shows the hierarchy in µNet3.

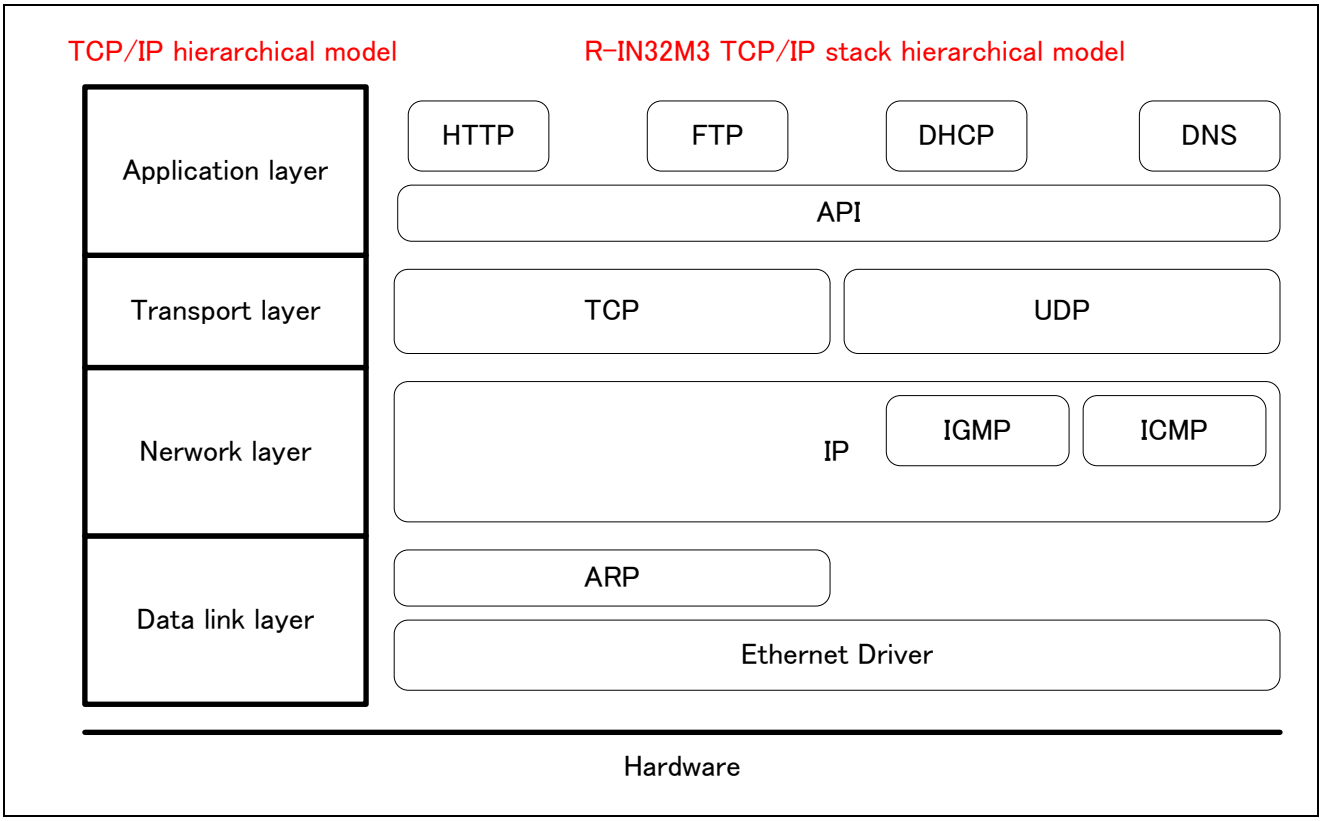


Fig. 2.1 Figure of TCP/IP hierarchical model and R-IN32M3 TCP/IP stack hierarchical model

2.1.3 IP address

Each node on the network has a specific logical number, it is called “IP address”. IP address has 32 bit address space, be represent as 192.168.1.32.

(1) Broadcast address

Broadcast means that the same data is simultaneously sent (broadcast communication) to all of the nodes in one network. The address is allocated particularly to broadcast called “Broadcast address”. Ordinarily in “Broadcast address”, all bits use 1 IP address “255.255.255.255”.

(2) Multicast address

Contrary to the broadcast that send data to all nodes, a special address is used to send data to a specific group only, is called “Multicast address”.

2.1.4 MAC (Media Access Control) address

Contrary to a logical address “IP address”, a physical address specify to an installed hardware in order to identify network devices such as LAN card is called “MAC address”. “MAC address” has 48-bit address space and to be notated 12-34-56-78-9A-BC or 12:34:56:78:9A:BC.

2.1.5 Port number

In network communication, a number identifies a program of communication partners is called “Port number”. The node that communicate through TCP/IP has IP address that corresponds to the address inside the network, but in order to communicate with more than one node at the same time, we use port number in the range from 1 to 65535 as auxiliary address. If port number is set 0 (PORT_ANY) then automatically ephemeral port number is allocated.

2.1.6 Big endian and little endian

The way multibyte numerical data is stored in memory is called “Endian”. “Big endian” refers to the way that store the most significant byte in the sequence. “Little endian” refers to the way that store the least significant byte in the sequence

It is determined that the header information is transmitted by “big endian” through TCP/IP.

2.1.7 Packet

The Unit of data transceiver is called “packet”. The packet includes 2 kinds of information. One contains actual stored data (data area) and the other contains the information used to manage as the information of source or destination of that data, error checking information (header area).

2.1.8 Host and node

Host refers to the computer that communicates on the network. And the connection points in a network such as server, client, hub, router, access point etc. are called “node”.

2.1.9 Address Resolution Protocol (ARP)

A protocol used to translate the physical address (MAC address) from logical address (In case of TCP/IP, that is IP address) is called “ARP”.

2.1.10 Internet Protocol (IP)

The protocol which executes the communication between nodes or node and gateway is called“IP (IP protocol)”.“IP (IP protocol)” is an very important protocol of the upper layer. The role of “IP” is to transfer data to the destination through the router based on the IP address without however ensuring their delivery, thus, ensuring the reliability of data is upper layer’s responsibility

“IP address” mentioned above is placed in the header of this “IP protocol”.

2.1.11 Internet Control Message Protocol (ICMP)

A protocol provides the function that is to notify errors occurred in IP network communication and verify the state of network status is called “ICMP”. There are echo request and echo reply messages are called Ping which most well-known.

2.1.12 Internet Group Management Protocol (IGMP)

The protocol executes IP Multicast is called “IGMP”. We can usually send the same data to many different hosts efficiently.

2.1.13 User Datagram Protocol (UDP)

A protocol provides the connectionless mode datagram communication service is called “UDP”. IP does not have interface with application. “UDP” is the protocol which helps to use that function from application. As a result, there is no way to notify that packets have arrived to the partner and the order of arrived packets may be changed so UDP does not sure the reliability of data.

2.1.14 Transmission Control Protocol (TCP)

A protocol which provides connection mode stream communication service is called “TCP”. “TCP” is known as upper layer of IP protocol, which provides a reliable communication as flow control, retransmission, error correction and sequence control.

2.1.15 Dynamic Host Configuration Protocol (DHCP)

When connecting to a network, a protocol which assigns automatically the necessary information such as IP address is called“DHCP”. To use“DHCP”, we have to prepare DHCP server and on server side, it’s necessary to prepare some IP addresses for DHCP client in advance (Address pool).

2.1.16 Hyper Text Transfer Protocol (HTTP)

A protocol used to transfer the contents such as HTML file of homepage or website is called “HTTP”. “HTTP” not only can transfer HTML file but also can send binary data which are displayed on WEB browser such as JPEG, GIF, PNG, ZIP file.

2.1.17 File Transfer Protocol (FTP)

We call the protocol which transfer files between hosts is “FTP”.

2.1.18 Domain Name System (DNS)

A name resolution mechanism which can exchange host name into IP address or IP address into host name (domain) is called DNS. In case of using “DNS”, it is possible to look up the host name based on IP address or look up IP address from the host name.

2.1.19 Socket

An endpoint for communication which applications use for communicating TCP/IP is called “socket”. “Socket” is constructed by IP address and port number. The applications, through specifying the socket to establish a connection, can transceive data without caring about any details of communication procedure. There are varieties of sockets depending on the protocol used in communication side. TCP socket uses TCP protocol to communicate data and UDP socket uses UDP protocol to communicate data. In R-IN32M3 TCP/IP stack, we use ID number to identify the socket which becomes an operational objective. The application utilizes ID number to invoke socket API.

2.1.20 Blocking and non-blocking

When calling some function, if it does not return until the action has completed, that is called “Blocking mode” and if it returns immediately without waiting for its completion, that is called “Non-blocking mode”.

For instance, in the socket API ofμNe3, the task calling the rcv_soc function in “Blocking mode” is placed in the waiting status until that action completes (until data can be received). Calling the rcv_soc function in “Non-blocking mode” will return immediately with an E_WBLK error code and the completion of that action (EV_RCV_SOC) is notified to callback function.

By default, the R-IN32M3 TCP/IP stack sockets are in “Blocking mode”, and in order to switch to “Non-blocking mode”, we have to use cfg_soc function and set up registration of callback function and callback event flag.

2.1.21 Callback function

The function used for notifying the status of protocol stack to the applications asynchronously is called “Callback function”.

2.1.22 Task context

All API functions of R-IN32M3 TCP/IP stack must be called from Task context.

Do not call the system call which is in status of waiting for tasks such as slp_tsk from network callback function. Besides, do not call all API functions of R-IN32M3 TCP/IP stack from network callback function.

2.1.23 Resource

The resource used in a program is called “Resource”. There include tasks, semaphores are called “Kernel objects” and memory.

※Please make reference to OS User Guide on details of “Kernel object” such as tasks, semaphores.

2.1.24 MTU

In communication network, MTU (Maximum Transfer Unit) is a value indicating the maximum amount of data that can be transferred by one-time transfer. Moreover, MTU also shows the maximum data size of the frame in data link layer. In addition, the minimum value indicated by MTU is 68 bytes.

Specifying the maximum data size depends on the protocol used in data link layer and in Ethernet interface generally uses 1500 bytes.

2.1.25 MSS

MSS (Maximum Segment Size) indicates the maximum data size of TCP packet. Therefore, MSS value can be calculated by the following formula.

MSS = MTU– (IP Header size+ TCP Header size (normally 40 bytes))

In case of Ethernet interface, the value of MSS is generally 1460 bytes.

2.1.26 IP reassembly - fragment

The maximum size of an IP packet is 64K bytes. However, in order that MTU of communication interface becomes a smaller value than the original, it’s necessary that IP module must divide IP packet into smaller pieces to send. This processing is called “IP fragmentation” and divided IP packet is called “IP fragment”.

Moreover, IP module of receiver side needs to combine the divided “IP fragment” and we call this process is “IP reassembly”.

2.2 Architecture of Network system

2.2.1 Block diagram of network system

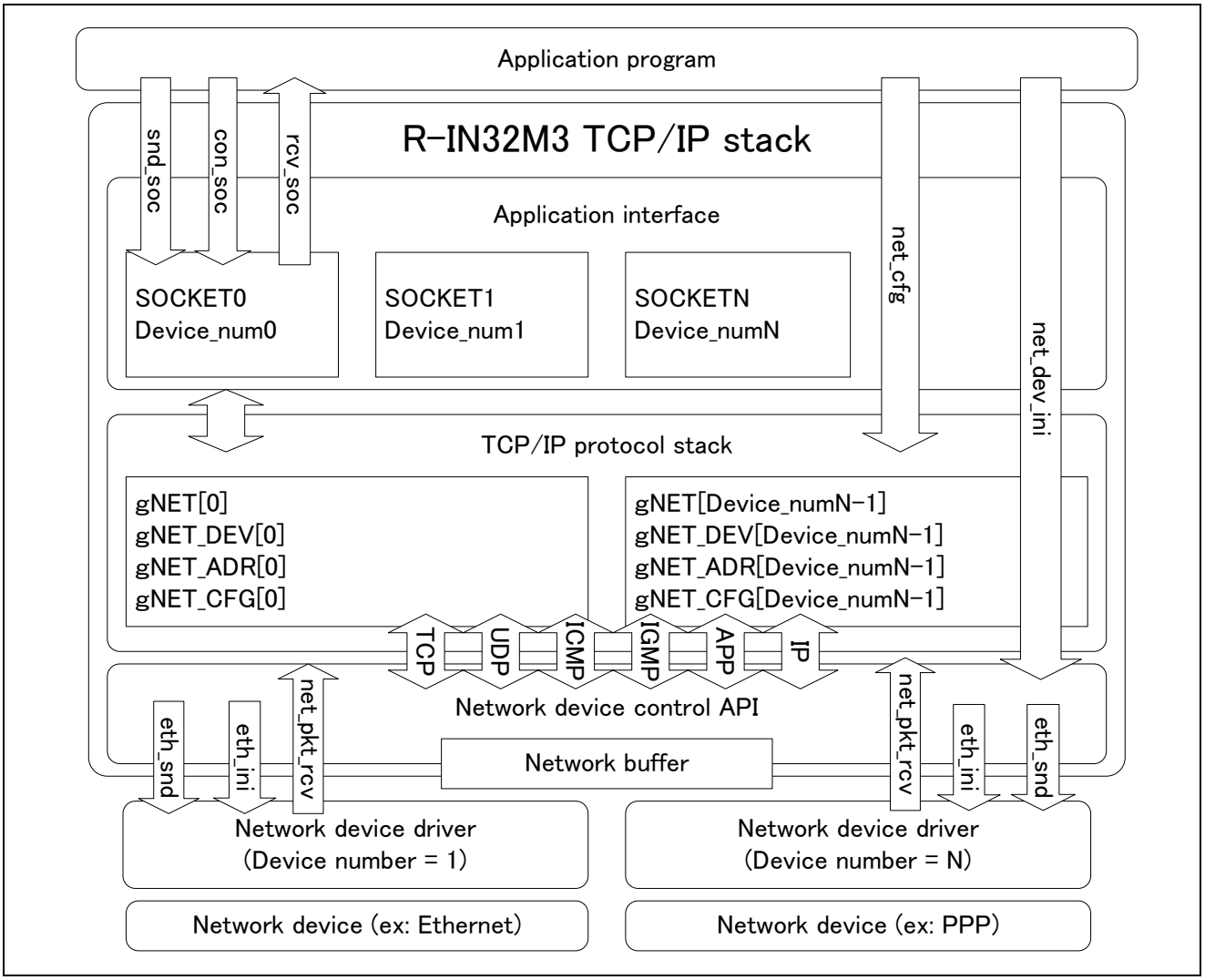


Fig. 2.2 Block diagram of network system

- Application program

The application program is used for network communication. It includes application protocols such as DHCP, FTP, Telnet, HTTP etc.

- Application Interface

Providing the interface (API) to utilize various network services such as transmission / reception of data or establishing connection to remote host.

In case of normal application, we have to specify socket ID and device number before using Application Interface.

- TCP/IP protocol stack

This program handles the network protocols such as TCP, UDP, ICMP, IGMP, IP and ARP.

- Network device control API

In network system, maybe there exist various network devices. Every device needs a device driver. And the network device control API absorbs the difference between these devices, provides interface in order to access unifiedly. Using device number from application program before accessing to the devices.

- Network device driver

A program that control network device. The content integration is different depending on the device.

In R-IN32M3 TCP/IP stack, it is provided standard Ethernet driver device.

- Network device

The hardware that execute the transmission and reception of actual network data. This refers to Ethernet, PPP (RS-232), and WLAN etc.

- Others

R-IN32M3 TCP/IP stack using the below OS Kernel objects:

Table 2.1 OS Kernel objects which are used in TCP/IP stack for R-IN32M3

Object	Object ID	Usage
Task	ID_NET_MAIN_TSK	R-IN32M3 TCP/IP stack startup task
Task	ID_TASK_TCP_TIM	R-IN32M3 TCP/IP stack time management task
Task	ID_TASK_ETH_SND	Ether driver send task
Task	ID_TASK_ETH_RCV	Ether driver receive task
Task	ID_TASK_PHY_LINK	Ether driver control task
Semaphore	ID_SEM_TCP	R-IN32M3 TCP/IP stack resource control semaphore
Event flag	ID_FLG_ETH_RX_MAC	Ether driver event flag
Event flag	ID_FLG_ETH_TX_MAC	Ether driver event flag
Event flag	ID_FLG_PHY_STS	Ether driver event flag
Event flag	ID_FLG_SYSTEM	Ether driver event flag
Mailbox	ID_MBX_ETH_SND	Ether driver mail box
Mailbox	ID_MBX_ETH_MEMPOL	Ether driver mail box

Table 2.2 Hardware ISR which are used in TCP/IP stack for R-IN32M3

The factor of Hardware ISR	Operation	Use information
PHY0_IRQn	set_flg()	PHY driver
PHY1_IRQn	set_flg()	PHY driver
ETHTXDMA_IRQn	set_flg()	Ethernet driver in transmit operation
ETHTXDERR_IRQn	set_flg()	Ethernet driver in transmit operation
ETHTX_IRQn	set_flg()	Ethernet driver in transmit operation
ETHTXFIFO_IRQn	set_flg()	Ethernet driver in transmit operation
ETHTXFIFOERR_IRQn	set_flg()	Ethernet driver in transmit operation
ETHRXDMA_IRQn	set_flg()	Ethernet driver in receive operation
ETHRXFIFO_IRQn,	set_flg()	Ethernet driver in receive operation
ETHRXDERR_IRQn	set_flg()	Ethernet driver in receive operation
ETHRXERR_IRQn	set_flg()	Ethernet driver in receive operation

2.3 Directory and file organization

These files as below are included in R-IN32M3 TCP/IP stack.

(1) Header File

/Source/Middleware/uNet3/Inc/

net_cfg.h	Default configuration macro of TCP/IP protocol stack
net_hdr.h	Definition of the necessary information to use TCP/IP protocol stack
	Please include this header file in source file of applications.

(2) Library files<R>

This folder stores the library that has already built the TCP/IP protocol stack in various processor mode, and the project files are used to build.

/Library/<TOOL>/

libunet3.a	TCP/IP protocol stack library
Libunet3bsd.a	TCP/IP protocol stack library (BSD interface)

<TOOL> depends on development tool chain. (ARM/GCC/IAR)

(3) Ethernet device driver file<R>

/Source/Driver/ether_uNet3/

DDR_ETH.c	Ethernet driver
DDR_PHY0.c	PHY driver for LAN1
DDR_PHY1.c	PHY driver for LAN2

/Source/Driver/ethsw/

ethsw.c	Ethernet Switch driver

/Include/ ether_uNet3/

DDR_ETH.h	Ethernet driver header
DDR_PHY.h	PHY driver common header
DDR_ETH_CFG.h	Ethernet driver configuration header
COMMONDEF.h	Ethernet driver common definition header

/Include/ ethsw/

ethsw.h	Ethernet Switch driver header

(4) Application protocol source file<R>

/Source/Middleware/uNet3/NetApp/

dhcp_client.h	DHCP client macro, prototype, definition etc.
dhcp_client.c	DHCP client source code
ftp_server.h	FTP server macro, prototype, definition etc.
ftp_server.c	FTP server source code
http_server.h	HTTP server macro, prototype, definition etc.
http_server.c	HTTP server source code
dns_client.h	DNS client macro, prototype, definition etc.
dns_client.c	DNS client source code
ping_client.h	ICMP echo request macro, prototype, definition etc.
ping_client.c	ICMP echo request (ping) source code.
sntp_client.h	SNTP client macro, prototype, definition etc.
sntp_client.c	SNTP client macro source code.
net_strlib.h	String library function definition.
net_strlib.c	String library function source code.

/Source/Middleware/uNet3/NetApp/ext/

dhcp_client.h	DHCP client extended version macro, prototype, definition etc.
dhcp_client.c	DHCP extended version client source code

(5) Sample source file

/Source/Project/uNet3_sample/

cgi_sample.c	CGI application sample
html.h	HTML data
kernel_cfg.c	OS resources configuration file
kernel_id.h	OS resources ID definition file
main.c	Main function
net_cfg.c	TCP/IP stack configuration file
net_sample.c	Network application sample

3. Overview functions of R-IN32M3 TCP/IP stack

3.1 Protocol stack

3.1.1 IP module

The IP module only receives and handles the arrived packets which has destination IP address matches with the IP address of local host. Other packets are not handled.

(1) IP Option

R-IN32M3 TCP/IP stack supports router warning option of internal IGMP in IP option only. IP options which do not support will be ignored. .

(2) TTL (Time to Live)

Default value of TTL in R-IN32M3 TCP/IP stack is set DEF_IP4_TTL(64). This value may be changed by using net_cfg(). In case of using net_cfg() to change the value of TTL, TTL value of all sockets are changed. In case that we want to change TTL value of each socket, please use cfg_soc().

(3) TOS (Type Of Service)

In R-IN32M3 TCP/IP stack, TOS is set DEF_IP4_TOS (0).

(4) Broadcast

Maybe receive broadcast or not depending on using net_cfg(). The initial value is set that ready to receive. Always can transmit broadcast. The broadcast setting is effective for all sockets but we cannot set up whether receive broadcast by socket unit.

Regarding to transceive broadcast, please use UDP socket.

(5) Multicast

In order to allow multicast reception, we use net_cfg() and register at the address of the multicast group which join to. Multicast group address may be registered by DEF_NET_MGR_MAX (8).

Always can send multicast. The multicast setting is effective for all sockets but we cannot set up whether receive multicast by socket unit.

TL used for transferring multicast is set DEF_IP4_MCAST_TTL (1). This value can also be changed by using net_cfg().

Do not support multicast loopback.

Regarding to transceive of multicast, please use UDP socket.

(6) MTU

In R-IN32M3 TCP/IP stack, DEF_PATH_MTU (1500 byte) is set as default value of MTU. This value can be configured by the configurator.

(7) IP reassembly / fragment

In R-IN32M3 TCP/IP stack, maximum size of IP packet is 1500 byte as default (This value is related to the value of network buffer). In order to increase the size of IP packet to maximum, we need to enlarge the network buffer. For example, in case that transceive 2048byte of UDP data, we need to increase the value of network buffer larger than the value is calculated from this formula (control header size (100 bytes) + IP header size (20bytes) + UDP header size (8bytes) + 2048).

The default value of IP reassembly process timeout is DEF_IP4_IPR_TMO(10 seconds). If the reassembly process cannot complete within this timeout, the reassembly process is cancelled, the ICMP error message (type 11: packet discarded by time excess) is sent to remote host.

The default number of times of the IP reassembly process is set DEF_NET_IPR_MAX(2). DEF_NET_IPR_MAX value expresses a value which host can execute IP reassembly process at the same time.

(8) IGMP

In R-IN32M3 TCP/IP stack, the timeout until the “report (reply)” message is sent to “query (group inquiry)” (from router) is set by DEF_IGMP_REP_TMO (10 seconds)

R-IN32M3 TCP/IP stack supports IGMPv2 and also supports IGMPv1 compatible function.

In case of getting query of IGMPv1, it will be changed into IGMPv1 mode and then processed. After that, within a certain time period, if there is no IGMPv1 message, it will be back to IGMPv2 mode. Timeout for returning from IGMPv 1 to IGMPv 2 is set by DEF_IGMP_V1_TMO (400 seconds).

(9) ICMP

R-IN32M3 TCP/IP stack supports messages of “echo response”, “echo request”, “time excess”.

3.1.2 ARP module

(1) Resolve ip address

R-IN32M3 TCP/IP stack will manage the mapping of IP address of host and physical address (MAC address). The administration table (conversion table) of this mapping is called ARP cache. ARP cache size is set by DEF_NET_ARP_MAX (8).

When sending IP packet to network, in case that there exists a compatible IP address which refers to ARP cache, it will send a packet to the destination that is the physical address has been recorded there. In case that there is no existing IP address, IP packet will be stored temporarily in queue, then, send broadcast ARP request packets. After receiving ARP response packets from remote host, record a received physical address in ARP cache newly. Then, remove IP packet from queue, send the packet to the newly acquired physical address.

Besides, ARP entry information is held in the cache table for a maximum of ARP_CLR_TMO (20 minutes).

(2) Address conflict detection

According RFC5227, R-IN32M3 TCP/IP stack will check whether Ipv4 address is non-duplicative in the same link. This feature is performed by API is called from application, when LAN interface boot up or link status changes.

After setting the IP address of the interface, the other host had set the same IP address, then the detected the conflict, R-IN32M3 TCP/IP stack will notify the application.

"ARP Probe" can detect whether the IP address that you will use is not already in use.

Other host did not respond to **"ARP Probe"**(IP address conflict is not), R-IN32M3 TCP/IP stack notify the other hosts that to use this IP address from now by sending the **"ARP Announce"**.

3.1.3 UDP module

UDP executes the transceiver of data without connecting to remote host.

(1) Sending data

Before sending data, we should use con_soc and associate a socket with a source address (IP address, port number). After that, we use snd_soc() to send data. The flow snd_soc() processing is described in the diagram as below.

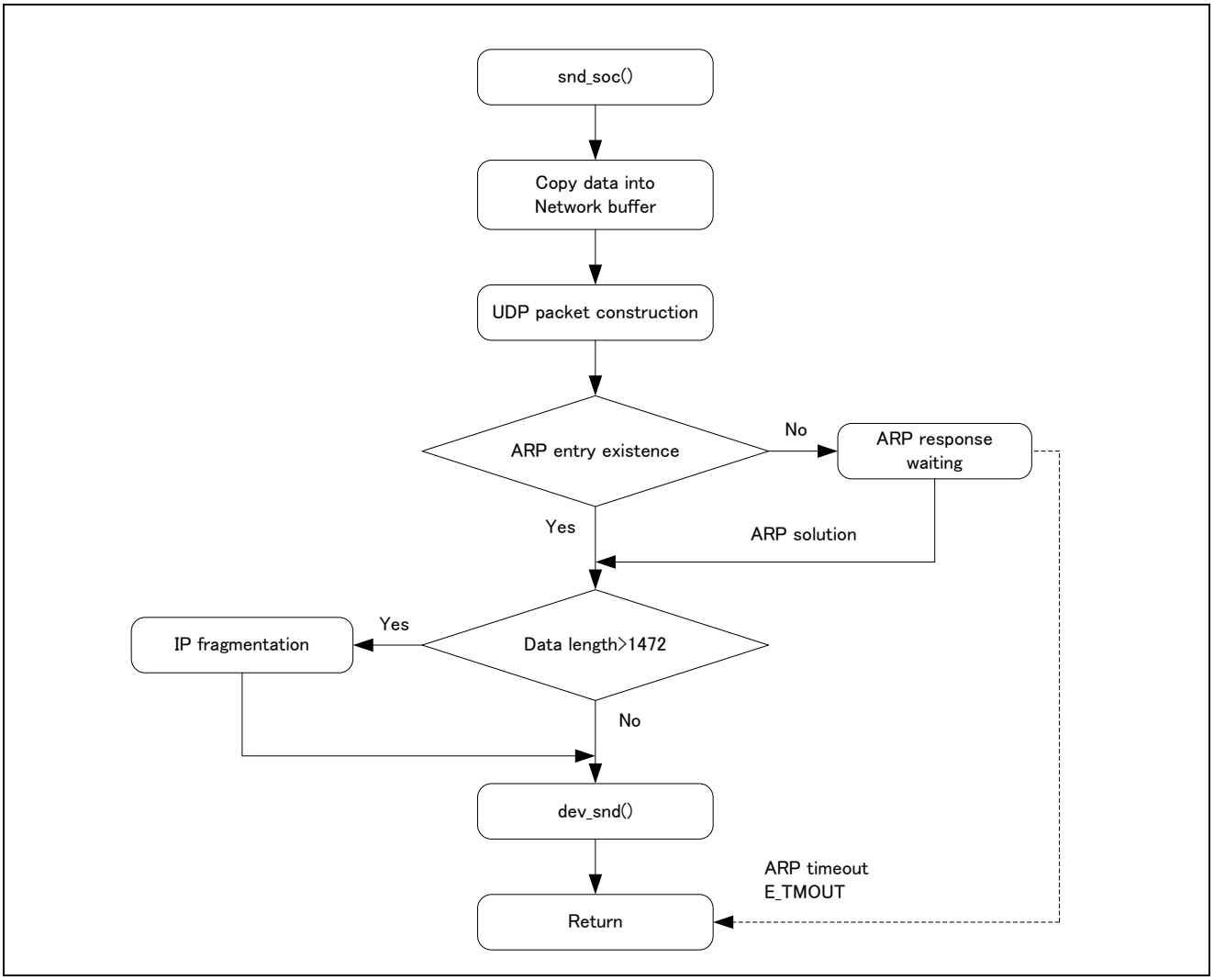


Fig. 3.1 The flow of snd_soc processing of UDP socket

4. The application data is copied into network buffer, adding UDP header such as port number,IP address of remote host,then construct UDP packet.
5. In case that cannot resolve MAC address of remote host by ARP protocol, it will return E_TMOUT error.
6. In default, the maximum size of transmission data is set 1472 bytes (DEF_PATH_MTU (1500 bytes) － IP header size－ UDP header size). In case of sending data with larger size than this, we need to set network buffer size. Regarding the details, please refer to the item of IP reassembly/fragment

(2) Data reception

Data reception is executed by using rcv_soc(). The flow of rcv_soc() processing is described in the diagram as below.

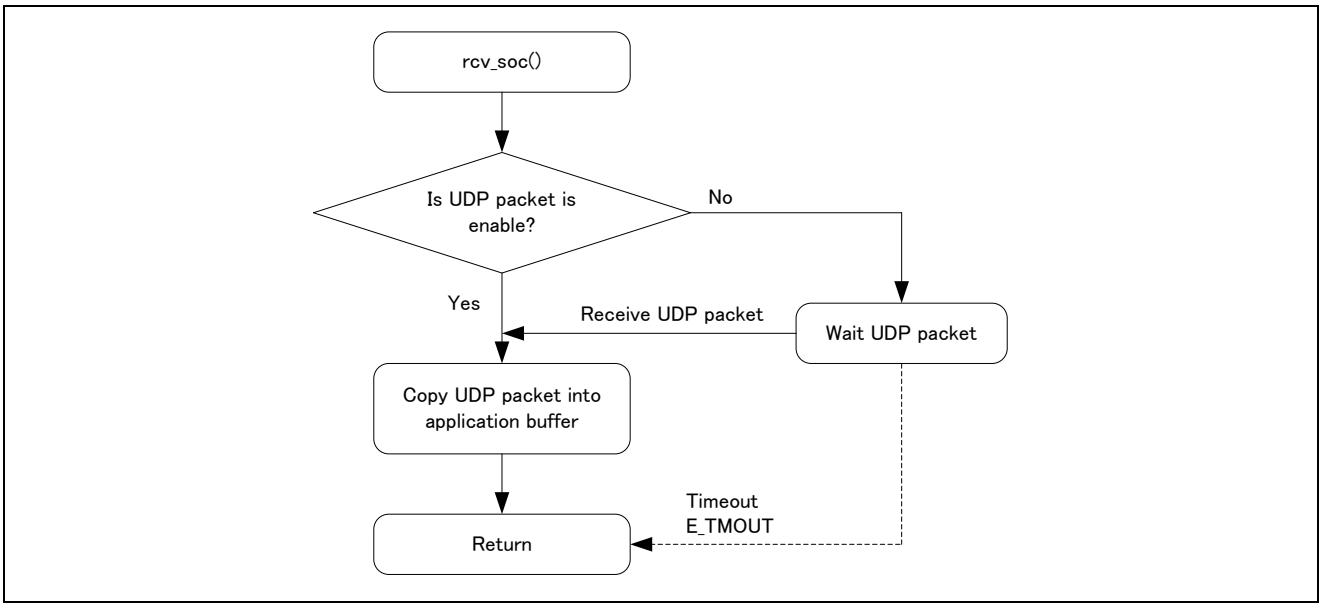


Fig. 3.2 The flow of rcv_soc processing of UDP socket

7. If UDP packet has not been received yet, enter a state of waiting for UPD packet reception. At that time, if it exceeds timeout of receiving socket, it will return E_TMOUT.
8. If received packet size is smaller than requested data size, copy into application buffer. In case that received packet with bigger size, just copy the request size into application buffer. Remaining part will be ignored.
9. In default, maximum size of reception data is set 1472 bytes (DEF_PATH_MTU (1500 bytes) - IP header size- UDP header size). In case of receiving data with larger size than this, we need to set network buffer size. Regarding the details, please refer to the item of IP reassembly/fragment.

3.1.4 TCP module

TCP is different from UDP. TCP is connection mode, so it can allocate sending party and channels before transceiving data. TCP sequence is described in the diagram as below.

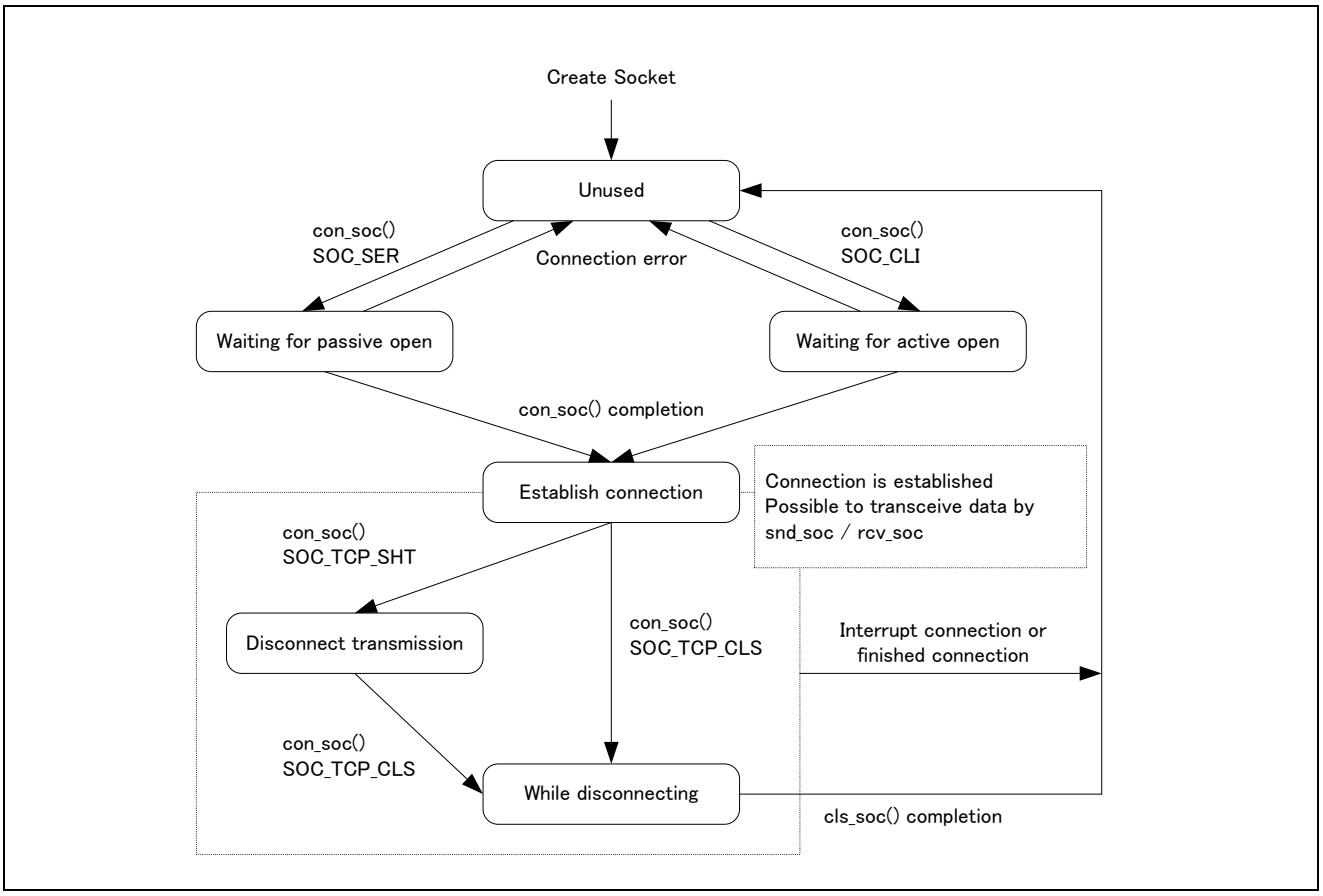


Fig. 3.3 TCP sequence

(1) Establishing connection

There are two modes of TCP connection, active and passive connection. Active connection that requires connect to remote host by itself. On the contrary, passive connection that wait for the connection from remote host.

Use con_soc() to connect, and need to specify active connection by SOC_CLI and passive connection by SOC_SER.

(2) Connection completion

In order to disconnect the connection, we use cls_soc(). Specify SOC_TCP_CLS in order to disconnect all the connection completely, and SOC_TCP_SHT to disconnect the transmit direction only.

(3) Data transmission

Use snd_soc() to send data. The flow of snd_soc() processing is described as below.

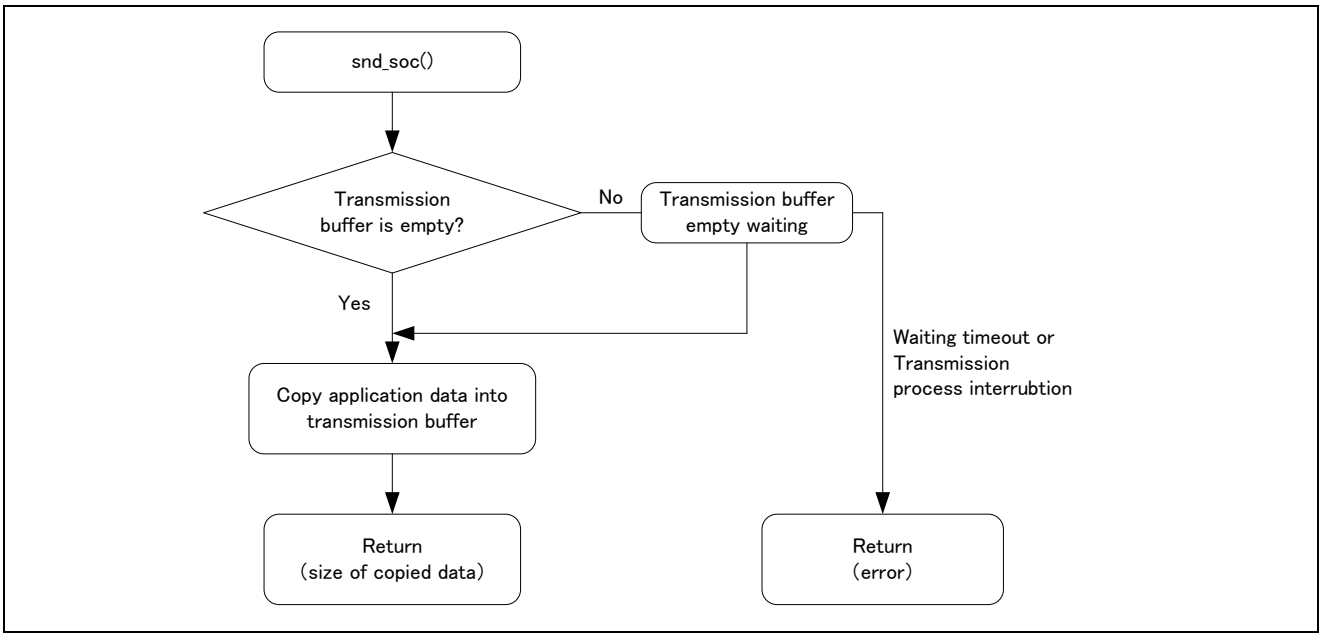


Fig. 3.4 TCP socket–Flow of snd_soc processing

10. Copy data of application into TCP transmission buffer. If copy is successful, TCP protocol will send data. If remote host received data, all data in TCP transmission buffer will be clear.

- TCP transmission buffer

It is necessary to specify transmission buffer size when create TCP socket. Buffer size has a range from 4 bytes to 32 kilobytes and aligns to 2 power 2.

(4) Data reception

Use rcv_soc() to send data. Received TCP packet firstly will be registered at TCP reception buffer. When rcv_soc() is called, it will be copied from TCP reception buffer into application buffer.

- TCP reception buffer (Window buffer)

It is necessary to specify reception buffer size when create TCP socket. Buffer size has a range from 4 bytes to 32 kilobytes and aligns to 2 power 2.

(5) Retransmission timeout

Timer sequence of resending is described in the diagram as below.

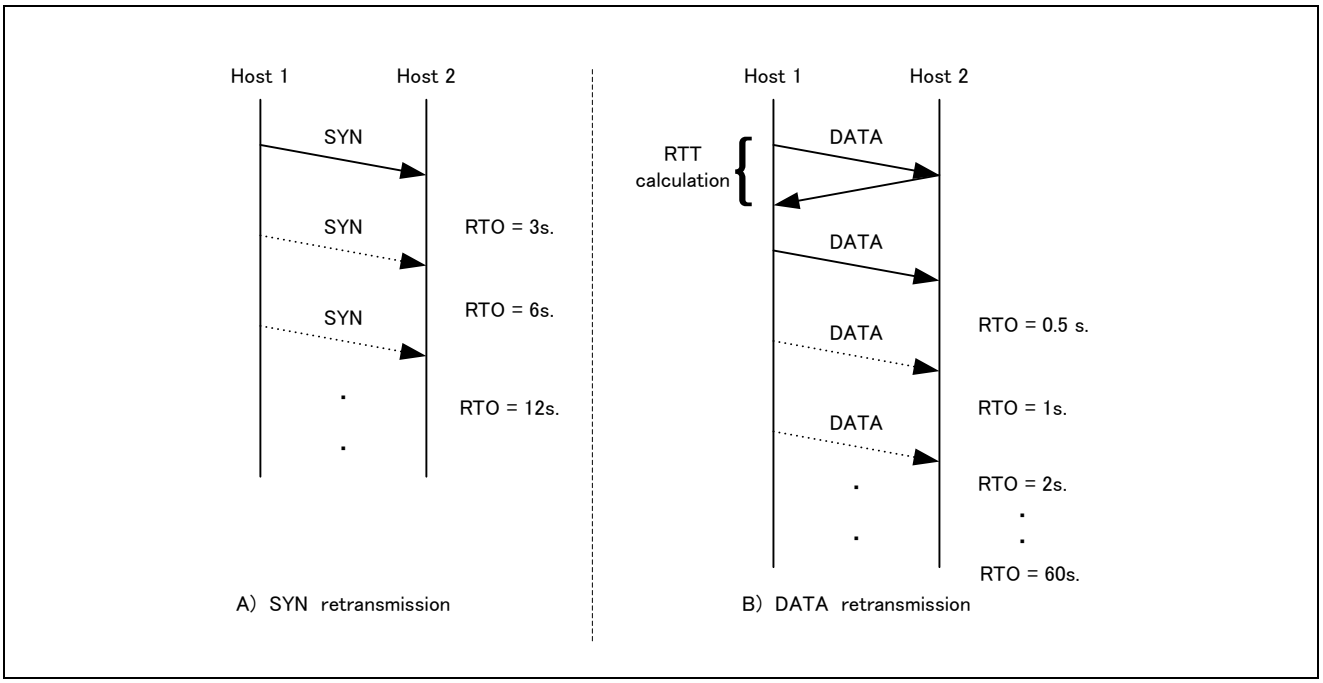


Fig. 3.5 An example of retransmission timer

In TCP, if there are not response of ACK packet within a certain time for any reason, segment without response will be sent again. The waiting time until retransmission action is executed is called "RTO" (Retransmission Time Out). Initial value of RTO is called "RTT" (Round Trip Time), is "4 times＋α" of "Time that packet makes round trip to the other). RTO value is increased twice every time resending action is done.

When retransmit SYN like the above A diagram, it uses DEF_TCP_RTO_INI (3 seconds) due to RTT value is not set. In the above B diagram of data retransmission, it calculates RTT value based on the previous successful transmission, that's 500 milliseconds.

RTO scope is set from DEF_TCP_RTO_MIN (500 ms) to DEF_TCP_RTO_MAX (60 s).

(6) Connection timeout

Connection timer sequence is described in the below diagram.

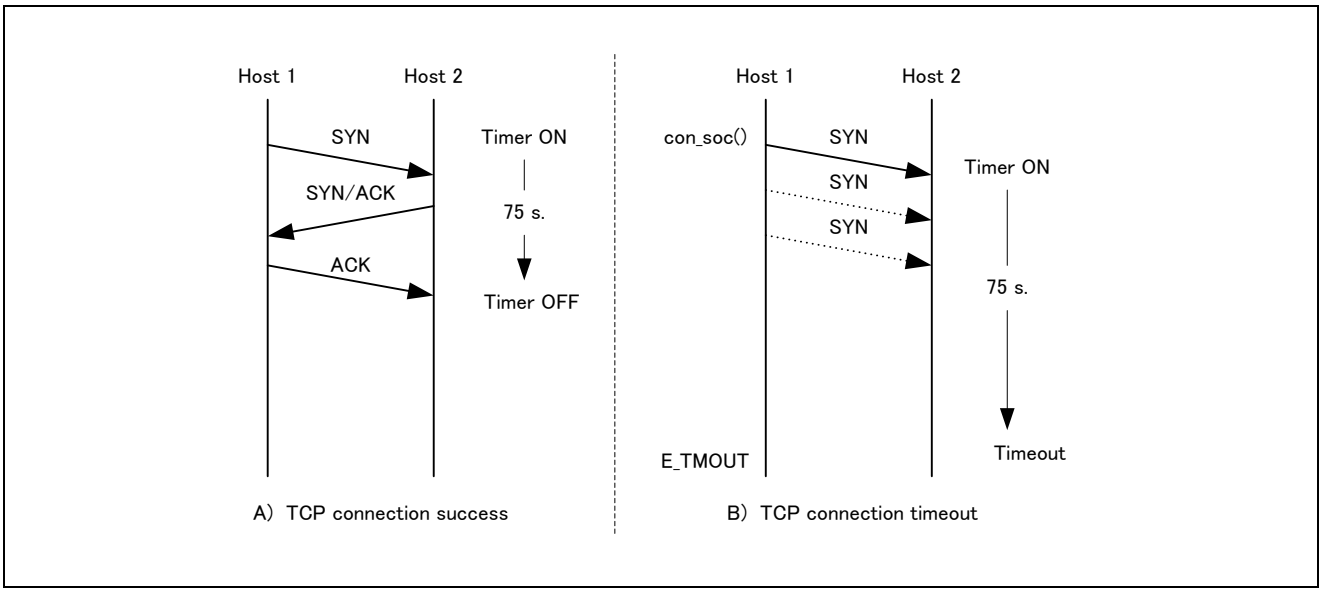


Fig. 3.6 An example of connection timeout

When call con_soc(), if this timer completes from starting up to three-way handshake timed out, it will return E_OK (A). If finish timeout, it will return E_TMOUT (B).

Timeout value of connection process (3-way handshake) is set DEF_TCP_CON_TMO (75 seconds).

※When create TCP socket, it can specify blocking timeout used in connection. If this value runs out of time, connection process will be interrupted immediately and con_soc() will return E_TMOUT.

(7) Transmission timeout

Transmission timeout is set DEF_TCP_SND_TMO (64 seconds). While communicating data, if there is no response from the partner even though passes DEF_TCP_SND_TMO, the connection will be disconnected.

(8) Disconnection timeout

Timeout of disconnection process is set DEF_TCP_CLS_TMO (64 seconds). If cls_soc() does not complete at DEF_TCP_CLS_TMO, connection will be forcibly disconnected and cls_soc() will return E_TMOUT.

※When create TCP socket, it can specify blocking timeout used in connection. If this value runs out of time, connection process will be interrupted immediately and cls_soc() will return E_TMOUT.

(9) Delay ACK timeout

Delay ACK timeout is set DEF_TCP_ACK_TMO (200 milliseconds).

(10) TCP congestion control

R-IN32M3 TCP/IP stack supports fast retransmit and fast recovery. Number of duplicate ACK is set DEF_TCP_DUP_CNT (4).

(11) Maximum Segment Size (MSS)

MSS is set DEF_TCP_MSS (1460 bytes).

(12) Keep Alive

R-IN32M3 TCP/IP stack supports TCP Keep Ailve.

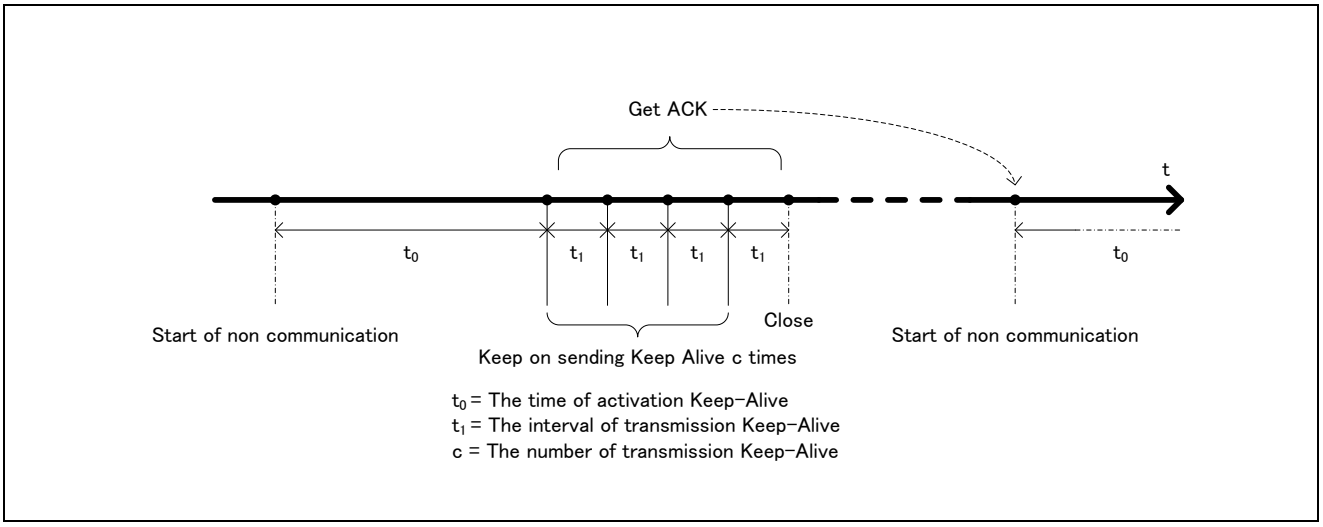


Fig. 3.7 Operation TCP Keep Alive

If Keep Alive feature is enabled (c > 0), after t_0 seconds in non-communication state, start the transmission of Keep Alive packet to the destination host.

Until it is transmitted c times, or get ACK from destination, R-IN32M3 TCP/IP stack will continue to send the Keep Alive packets at intervals of t_1 seconds.

If no response is obtained in c times Keep Alive packet, then R-IN32M3 TCP/IP stack close TCP connection.

It does not disconnect TCP connection automatically if Keep Alive feature is disable (c = 0)

3.2 Network device driver

Because protocol stack will access to device driver through **T_NET_DEV structure**, so the information as device name, device number, the functions of device driver must be registered in **T_NET_DEV structure** in advance. Protocol stack specify and access to the device which is registered in **T_NET_DEV** by device number.

3.2.1 Device structure

```
typedef struct t_net_dev {
        UB      name[8];        /* Device name*/
        UH      num;            /* Device number */
        UH      type;           /* Device type */
        UH      sts;            /*Reserve*/
        UH      flg;            /*Reserve */
        FP      ini;            /*Pointer to dev_ini function*/
        FP      cls;            /* Pointer to dev_cls function*/
        FP      ctl;            /* Pointer to dev_ctl function*/
        FP      ref;            /* Pointer to dev_ref function*/
        FP      out;            /* Pointer to dev_snd function*/
        FP      cbk;            /* Pointer to dev_cbk function*/
        UW      *tag;           /* Reserve*/
        union   cfg;            /* MAC address */
        UH      hhdrsz;         /* Device header size */
        UH      hhdrofs;        /* Position writing network buffer */
} T_NET_DEV;
```

(1) Device number

Set unique number to specify device. Protocol stack will use this number to access to the device. Device number should be numbered consecutively from 1.

(2) Device name

Set the name in order to specify the device. The length of device name should be under 8 bytes long.
For example: eth0, eth1 etc.

(3) Device type

Set type of network device. There are some as below.

Device type	Meaning
NET_DEV_TYPE_ETH	Ethernet device
NET_DEV_TYPE_PPP	PPP device

(4) Function of driver device

Device driver needs to support the below functions. These functions are called from appropriate protocol stack.

Prototype	Description	Requirement
ER dev_ini(UH dev_num)	Device initialization	Require
ER dev_cls(UH dev_num)	Device release	No require
ER dev_snd(UH dev_num, T_NET_BUF *pkt)	Send packet to network	Require
ER dev_ctl(UH dev_num, UH opt, VP val)	Device control	No require
ER dev_ref(UH dev_num, UH opt, VP val)	Device status acquisition	No require
void dev_cbk(UH dev_num, UH opt, VP val)	Notify event from device (callback function)	No require

(5) MAC address

Set unique value to specify hardware.

```
union {
    struct {
        UB      mac[6];   /* MAC address */
    }eth;
} cfg;
```

(6) Device header size<R>

Header size of network device header size is set.

(7) Position writing network buffer <R>

Network buffer data offset is set. This parameter must be “42”.

3.2.2 Interface

dev_ini	Device initialization

【Format】

ER ercd = dev_ini(UH dev_num);

【Parameter】

UH	dev_num	Device number

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_ID	Device number is wrong
E_OBJ	Already initialized
E_PAR	Illegal value set in T_NET_DEV
<0	Other errors (implementation dependent)

【Explanation】

Initialize device. This function is called to initialize device from protocol stack. Before calling this function, it is necessary to register device information in T_NET_DEV.

dev_cls	Device release

【Format】

ER ercd = dev_cls(UH dev_num);

【Parameter】

UH	dev_num	Device number

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_ID	Device number is wrong
E_OBJ	Already released

【Explanation】

Release device.

dev_ctl	Device control

【Format】

ER ercd = dev_ctl(UH dev_num, UH opt, VP val);

【Parameter】		
UH	dev_num	Device number
UH	opt	Control code
VP	val	Value to be set
【Return value】		
ER	ercd	Successful completion (E_OK) or error code
【Error code】		
E_ID	Device number is wrong	
E_PAR	Illegal parameter	
E_OBJ	Already released	

【Explanation】

The operation of this function is implementation dependent.

dev_ref	Device status acquisition

【Format】

ER ercd = dev_ref(UH dev_num, UH opt, VP val);

【Parameter】		
UH	dev_num	Device number
UH	opt	Status code
VP	val	Acquire value
【Return value】		
ER	ercd	Successful completion (E_OK) or error code
【Error code】		
E_ID	Device number is wrong	
E_PAR	Illegal parameter	
E_OBJ	Already released	

【Explanation】

The operation of this function is implementation dependent.

dev_snd	Packet transmission

【Format】

ER ercd = dev_snd (UH dev_num, T_NET_BUF *pkt);

【Parameter】

UH	dev_num	Device number
T_NET_BUF	*pkt	Pointer to network buffer

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_WBLK	Packet is registered in queue (not error)
E_ID	Device number is wrong
E_PAR	Illegal parameter
E_TMOUT	Packet transmission timed out
E_OBJ	Device status was wrong already

【Explanation】

This function transmits packet to Ethernet.

An example of integration

```
ER dev_snd(UH dev_num, T_NET_BUF *pkt)
{
/* Copy to Ethernet frame (IP/TCP/UDP/Payload) */
memcpy(txframe,  pkt->hdr,  pkt->hdr_len);
  /* Transmit to network */
  xmit_frame(txframe);
  return E_OK;
}
```

In the above example, the process of protocol stack is blocked by device driver. The next example shows the example that using queue and no blocking.

Non-blocking example

```
ER dev_snd(UH dev_num, T_NET_BUF *pkt)
{
queue_tx(pkt);      /* register packet in queue */
return E_WBLK;   /* Non-blocking */
}

void queue_tx_task(void)
{
dequeue_tx(pkt); /* Removing packet from queue */
/* Copy to Ethernet frame (IP/TCP/UDP/Payload) */
memcpy(txframe,  pkt->hdr,  pkt->hdr_len);
xmit_frame(txframe);   /* Transmit to network */
if (transmission timeout) {
pkt->ercd = E_TMOUT;     /* Set time out */
}
net_buf_ret(pkt);
}
```

In dev_snd transmission process is not executed, packet will register in queue and return E_WBLK. Actual packet transmission process is executed by another task and release of network buffer is also executed there too.

dev_cbk	Device event notification

【Format】

void dev_cbk(UH dev_num, UH opt, VP val);

【Parameter】

UH	dev_num	Device number
UH	opt	Event code
UH	val	Event value

【Return value】

None

【Error code】

None

【Explanation】

This function is to notify an event to the application from device driver. This function is implementation dependent.

3.2.3 packet routing

To send a packet to the upper protocol stack from device driver, it uses the following API.
※This API cannot be used from Applications.

net_pkt_rcv	Sending packet to protocol stack

【Format】

```
void net_pkt_rcv(T_NET_BUF *pkt);
```

【Parameter】

T_NET_BUF	*pkt	Pointer to network buffer

【Return value】

None

【Error code】

None

【Explanation】

This function is to send packet to the upper protocol. The below example shows the example for sending packet to upper protocol stack from device driver.

Example

```
/* Network buffer allocation */
T_NET_BUF *pkt;
net_buf_get(&pkt, len, TMO);

/* Set received Ethernet header to network buffer */
pkt->hdr = pkt->buf + 2;
pkt->hdr_len = ETH_HDR_SZ;
memcpy(pkt->hdr, rx_frame, pkt->hdr_len);

/* Set received IP payload to network buffer */
pkt->dat= pkt->hdr + pkt->hdr_len;
pkt->dat_len = rx_frame_len – pkt->hdr_len;
memcpy(pkt->dat, rx_frame + pkt->hdr_len, pkt->dat_len);

/* Device information setting*/
pkt->dev = dev;

/* Transfer network buffer to protocol stack */
net_pkt_rcv(pkt);
```

Release of network buffer is executed by net_pkt_rcv(). net_pkt_rcv() must be called from task context.

3.2.4 T_NET_DEV information registration example<R>

T_NET_DEV information registration example is showed as bellows.

T_NET_DEV information registration example

```
T_NET_DEV gNET_DEV[] = {
    {
        "lan0",                 /* Device Name          */
        1,                      /* Device Number        */
        NET_DEV_TYPE_ETH,   /* Device Type          */
        0,                      /* Status               */
        0,                      /* Flags                */
        eth_ini,                /* Device Init          */
        eth_cls,                /* Device Close         */
        eth_ctl,                /* Device Configure */
        eth_sts,                /* Device Status        */
        eth_snd,                /* Device Transmit    */
        eth_cbk,                /* Device Callback    */
        0,
        {{{ 0x12, 0x34, 0x56, 0x78, 0x9A, 0xBC }}},   /* MAC Address */
        ETH_HDR_SZ,                                   /* Link Header Size */
        CFG_NET_BUF_OFFSET                            /* Network buffer data Offset */
    }
};
```

3.3 Memory management

In protocol stack, it uses network buffer in memory management. By using network buffer, it can allocate the empty block of memory actively. The following diagram shows an example of memory allocation. First, device driver which receives data from hardware will use API network buffer, then allocate memory (net_buf_get). Next, it will set necessary information in allocated memory and then send packet to the upper layer protocol stack (net_pkt_rcv).

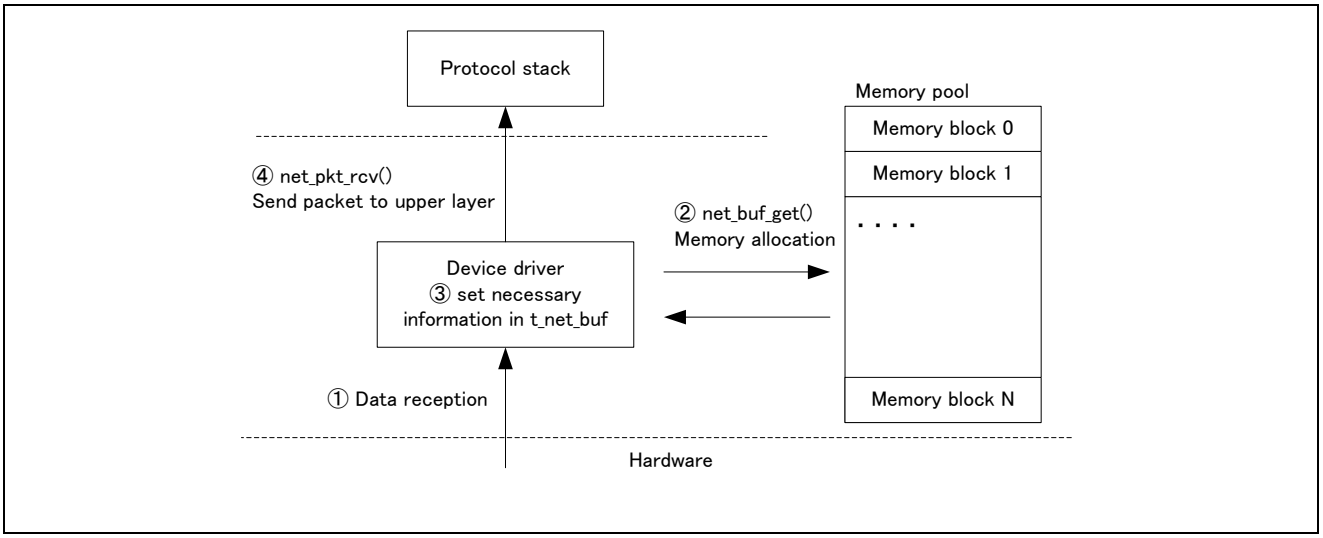


Fig. 3.8 Memory allocation diagram

3.3.1 Network buffer

In R-IN32M3 TCP/IP stack, block size uses maximum 8 memory pool with 1472byte fixed length. Network buffer provides the mechanism that allocate or free memory from this memory pool.

Network buffer organization (T_NET_BUF)

```
typedef struct t_net_buf {
        UW          *next;      /*Reserve */
        ID          mpfid;      /* ID memory pool */
        T_NET       *net;       /* Network interface */
        T_NET_DEV   *dev;       /* Network device */
        T_NET_SOC   *soc;       /* Socket */
        ER          ercd;       /* Error code */
        UH          flg;        /* Flag used to control protocol stack */
        UH          seq;        /* Fragment sequence*/
        UH          dat_len;    /* Data size of packet */
        UH          hdr_len;    /* Header size of packet */
        UB          *dat;       /* Showing data position in packet (buf) */
        UB          *hdr;       /* Showing header position in packet (buf) */
        UB          buf[];      /* Actual packet*/
} T_NET_BUF ;
```

The R-IN32M3 TCP/IP stack uses T_NET_BUF to transceive packet between protocol and device driver or the protocols.

In TCP/IP, the actual packet data are stored in ‘buf’,‘*dat’,‘*hdr’, ‘hdr_len’,‘dat_len’ are used to access to that.

(1) The access between protocol stack and device driver by network buffer<R>

Member	Send (protocol stack->driver)	Receive (driver->protocol stack)
dev	This is set for &gNET_DEV[dev_num-1]. dev_num is specified by application.	This is set for &gNET_DEV[eth_dev_num-1] eth_dev_num is set at initialization.
ercd	This shows the reason why driver fails to send. If driver succeed to send, this remains the size specified by protocol stack.	Not used.
flg	This controls whether hardware checksum is enabled or disabled; -HW_CS_TX_IPH4(0x0040) (IP header checksum) -HW_CS_TX_DATA(0x0080) (payload data checksum)	This controls whether hardware checksum is enabled or disabled; -HW_CS_TX_IPH4(0x0040) (IP header checksum) -HW_CS_RX_DATA(0x0020) (payload data checksum) If above checksum result has an error, please set below bits: -HW_CS_IPH4_ERR(0x0100) (IP header checksum error) -HW_CS_DATA_ERR(0x0200) (payload data checksum error)
hdr/hdr_len	This is set the head address and size of frame data which protocol stack sends. Driver sends data addressed between hdr and hdr_len offset.	This Is set the head address and size of frame data which driver received data. (In the case of Ethernet frame, header size is 14 Bytes)
dat/dat_len	Not used.	This is set head address of data and data size following the frame header received by driver. (In the case of Ethernet, dat shows the position shifted from hdr to hdr_len offset.)
buf[]	Packet This stores actual packet data. buf[0] and buf[1] are 4Byte alignments control buffer. The data to send or receive can be written upper buf[2].	

3.3.2 API network buffer

※This API network buffer cannot be used from application.

net_buf_get	Network buffer allocation

【Format】

```
ER ercd = net_buf_get(T_NET_BUF **buf, UH len, TMO tmo);
```

【Parameter】

T_NET_BUF	**buf	Address of buffer that allocate memory
UH	len	Number of allocating bytes
UH	tmo	Timeout specification

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_PAR	Set wrong parameter value
E_NOMEM	Unable to allocate memory
E_TMOUT	Timeout

【Explanation】

Allocate memory from memory pool. Allocated buffer address returns to buf.

net_buf_ret	Network buffer release

【Format】

```
void net_buf_ret(T_NET_BUF *buf);
```

【Parameter】

T_NET_BUF	**buf	Address of buffer that free memory

【Return value】

None

【Error code】

None

【Explanation】

Give back memory to the memory pool. If the socket is associated with network buffer, notify the free memory event to the socket.

3.4 Memory processing I / O

Comparison and writing process of contiguous memory occurred in the protocol are able to defined by user, so that it does not depend on device or compilation environment.

For devices with features DMA, Processing memory copy can use the DMA transfer instead of the memcpy() of standard library.

3.4.1 Memory processing I / O

※memory I/O API must be defined in application always.

net_memset	Fill block of memory	

【Format】

VP net_memset(VP d, int c, UINT n);

【Parameter】

VP	d	Pointer to the block of memory to fill
int	c	Value to be set
UINT	n	Number of bytes to be set

【Return value】

VP	d	Pointer to the block of memory to fill

【Explanation】

If the memory settings are successful, please return the destination pointer that is specified in the argument.

net_memcpy	Copy bytes in memory	

【Format】

VP net_memcpy(VP d, VP s, UINT n);

【Parameter】

VP	d	Pointer to the destination of memory
VP	s	Pointer to the source of data
UINT	n	Number of bytes to copy

【Return value】

VP	d	Pointer to the destination of memory

【Explanation】

If the memory copies are successful, please return the destination pointer that is specified in the argument.

net_memcmp	Compare two blocks of memory

【Format】

int net_memcmp(VP d, VP s, UINT n);

【Parameter】

VP	d	pointer to blocks of memory1
VP	s	pointer to blocks of memory2
UINT	n	Number of bytes to compare

【Return value】

int	Comparison result

【Explanation】

Please return 0 if the same value in the specified number of bytes. Otherwise, please return the non-zero.

3.5 Ethernet device driver<R>

This device driver is for Ethernet MAC or Ethernet Switch included in R-IN32M3. Ethernet device driver is used by calling from network device driver.

This device driver functions are showed below.

- PHY mode set/get
- PHY speed set/get
- Receive frame filtering
- Dynamic configuration for multicast address filter
- Raw data send/receive API
- Direct MAC mode / Ether Switch mode
- Blocking transmit / non-blocking transmit
- VLAN

3.5.1 Ethernet device driver structure

Ethernet device driver operates with PHY driver which controls MDIO interface. This driver structure is showed below.

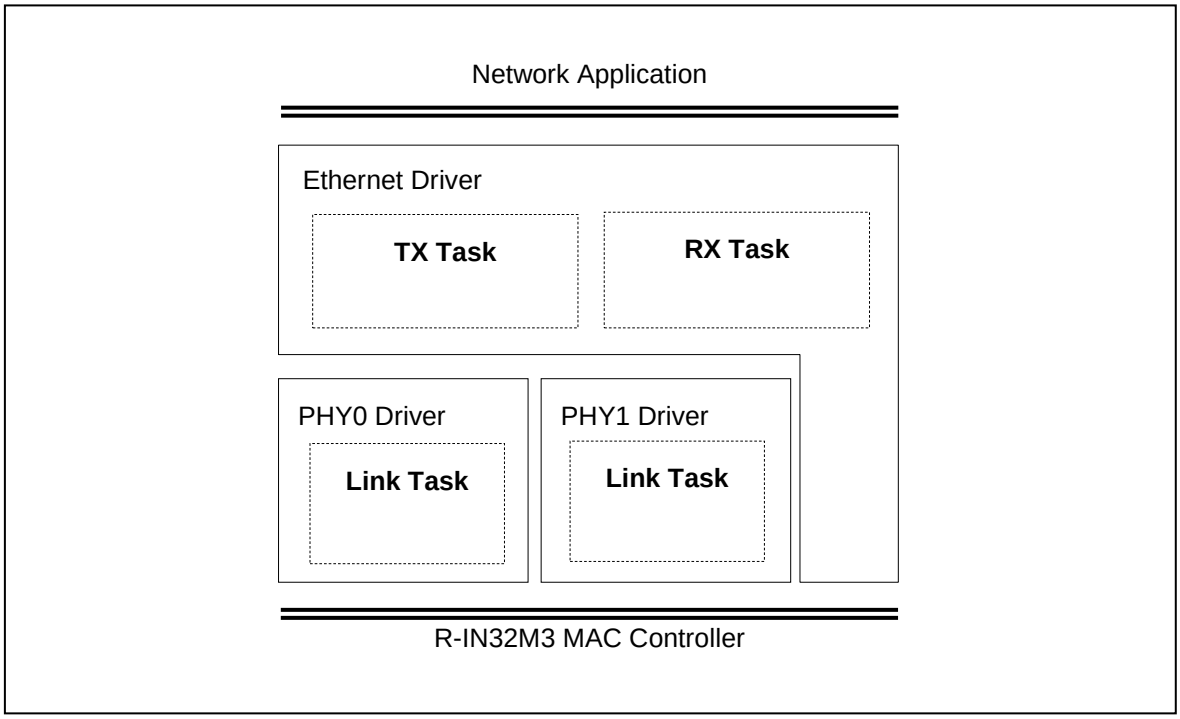


Fig.3.9 Ethernet device driver structure

3.5.2 Ethernet device driver API

3.5.2.1 Ethernet driver initialization - eth_ini()

【Prototype】

ER eth_ini(UH dev_num)

【Operation】

Initialize Ethernet driver

【Parameter】

UH	dev_num	Device number (1)

【Return value】

ER	E_OK	Success initialization
	E_ID	Undefined device number
	E_PAR	Invalid device number
	Others	Task wake up error, PHY driver initialization error

【Explanation】

This API initialize PHY and MAC controller, and wake up the task which controls Ethernet driver. This function must be called before Ethernet driver is used.

3.5.2.2 Ethernet driver closed - eth_cls()

【Prototype】

ER eth_cls(UH dev_num)

【Operation】

Ethernet driver is closed

【Parameter】

UH	dev_num	Device number (1)

【Return value】

ER	E_OK	Exit without error

【Explanation】

PHY, MAC controller stops.

3.5.2.3 Ethernet frame transmit - eth_snd()

【Prototype】

ER eth_snd(UH dev_num, T_NET_BUF *pkt)

【Operation】

Ethernet frame transmit

【Parameter】

UH	dev_num	Device number(1)
UH	pkt->hdr	Address for transmit data
UB*	pkt->hdr_len	Transmit data length

【Return value】

ER	E_OK	Success for transmit
	E_TMOUT	Link down
	E_WBLK	Non-blocking reception (Only when non-blocking transit)
	E_NOMEM	No enough memory
	E_SYS	MAC controller error

【Explanation】

When blocking transmit, this function returns after waits the interrupt for transmit complete. When non-blocking transmit, this function returns with E_WBLK after transmit success. If E_WBLK is returned, Ethernet driver calls back “eth_raw_snddone()” function when Ethernet frame transmit completed.

3.5.2.4 Ethernet frame transmit end report - eth_raw_snddone()

【Prototype】

void eth_raw_snddone(T_NET_BUF *pkt)

【Operation】

Ethernet frame transmit complete call-back function

【Parameter】

T_NET_BUF*	pkt	pkt specified to eth_snd()
ER	pkt->ercd	Transmit result

【Return value】

void

【Explanation】

Ethernet driver is called when non-blocking transmit is completed. This function needs to be registered by application before it's used. How to registration is showed below.

```
/* Function body of transmit complete note */
void eth_raw_snddone(T_NET_BUF *pkt)
{
}

/* Registration to transmit completion report function */
eth_ctl(1, ETH_OPT_RAW_SNDDONE, (VP)eth_raw_snddone);
```

The TX task must not be stopped, because this function operates under TX task.

3.5.2.5 Ethernet frame reception report - eth_raw_rcv()

【Prototype】

void eth_raw_rcv(VP fram, UH len)

【Operation】

Ethernet frame reception report function

【Parameter】

VP	fram	Reception data address
UH	len	Reception data length

【Return value】

void

【Explanation】

When Ethernet driver receive a frame, this function is called. This function needs to be registered to application before it is used. Registration example shows below.

```
/* Receive report function */
void eth_raw_rcv(VP p, UH len)
{
}

/* Receive report function registration */
eth_ctl(1, ETH_OPT_RAW_RXFNC, (VP)eth_raw_rcv);
```

Rx task must not be stopped because this function operates Rx task. If Ethernet driver is shared with TCP/IP stack, this function is called in driver earlier than in TCP/IP stack. Therefore, received frame data cannot be modified.

3.5.2.6 PHY ability setting - set_phy_mode()

【Prototype】

ER set_phy_mode(PHY_MODE *mode)

【Operation】

PHY ability setting

【Parameter】

PHY_MODE*	mode	PHY ability
UW	mode->mode	Speed / Duplex
UB	mode->nego	Auto-negotiation on(TRUE)/off(FALSE)
UB	mode->ch	Target PHY channel

【Return value】

ER	E_OK	Success
	E_PAR	Invalid parameter
	others	PHY driver configuration error

【Explanation】

Application can configure PHY ability anytime. The configuration of speed and duplex is selected from Table. 3.1. Target PHY is configured to ETH_INT_MII_PHY0 or ETH_INT_MII_PHY1.

```
struct PHY_MODE pmod;

pmod.mode = LAN_AUTO_ABILITY;
pmod.nego = TRUE;
pmod.ch = ETH_INT_MII_PHY0;

set_phy_mode(&pmod);
```

Table. 3.1 PHY ability setting

Value	Description
LAN_10T_HD	10M/Half-duplex
LAN_10T_FD	10M/Full-duplex
LAN_100TX_HD	100M/Half-duplex
LAN_100TX_FD	100M/Full-duplex
LAN_1000T_HD	1G/Half-duplex
LAN_1000T_FD	1G /Full-duplex
LAN_AUTO_ABILITY	Auto select

3.5.2.7 Get PHY ability - get_phy_mode()

【Prototype】

ER get_phy_mode(PHY_MODE *mode)

【Operation】

Get PHY ability

【Parameter】

PHY_MODE*	mode	PHY ability

【Return value】

ER	E_OK	Success
	E_PAR	Invalid parameter
	その他	PHY driver ability get error

【Explanation】

This function is used to get PHY ability (speed, duplex, auto-negotiation on/off), and link status. Application can get PHY ability anytime. Example is showed below.

```
struct PHY_MODE pmod = {0};

/* Target PHY is set by ETH_INT_MII_PHY0 or ETH_INT_MII_PHY1 */
pmod.ch = ETH_INT_MII_PHY0;
get_phy_mode(&pmod);
```

pmod.mode shows PHY ability (reference Table. 3.1).
pmod.nego shows auto-negotiation enabled(TRUE) or disabled(FALSE).
pmod.link shows link-up(TRUE) or link-down(FALSE).

If a PHY is link-down, please notice that PHY ability shows invalid value.

3.5.2.8 Multicast address filter mode setting - set_mcast_filter_mode()

【Prototype】

ER set_mcast_filter_mode(UINT mode)

【Operation】

Set multicast address filter mode

【Parameter】

UINT	mode	Filter mode

【Return value】

ER	E_OK	Success
	E_PAR	Invalid parameter

【Explanation】

Filter mode has three modes showed below.

Value	Mode
MCRX_MODE_ALLOW	All multicast address receive mode
MCRX_MODE_DENY	Denied to receive multicast address mode
MCRX_MODE_FILTER	Specified multicast address receive mode

Caution 1 When independent address is set, choose MCRX_MODE_FILTER.

Caution 2 After MCRX_MODE_DENY is set, already registered multicast address is deleted all.

3.5.2.9 Add multicast address filter - add_mcast_filter()

【Prototype】

ER add_mcast_filter(MAC_FILTER *adr)

【Operation】

Add multicast address to receive

【Parameter】

MAC_FILTER*	adr	Multicast address to receive
UB	adr->mac[6]	Multicast address to add
UB	adr->bitnum	Valid bit number (0, 40-48)

【Return value】

ER	E_OK	Success
	E_PAR	Invalid parameter

【Explanation】

Filter mode must be set to MCRX_MODE_FILTER to add multicast address for receive.

Multicast address is shown as combination with lower 23 bits of class D IP address (1st octets is 0xE0~0xEF(224~239)) and upper 25 bits (0x01.0x00.0x5e.0x00/25). Application has to calculate receive MAC address from entering multicast IP address. Valid bits are specified 40 bits (5 octets) to 48 bits bit-by-bit. If 0 is set, it seems to be no valid bits (equal 48).

In case that all MAC address 01:00:5e:00:01:* (* is any value) can be received, the example is showed below.

```
MAC_FILTER adr;
UB macadr[] = {0x01, 0x00, 0x5e, 0x00, 0x01, 0x00};

memcpy(&adr.mac[0], macadr, 6);
adr.bitnum = 40;
add_mcast_filter(&adr);
```

Note: Please add the multicast address (224.0.0.1) which targeget all nodes. If this address is not added, receive operation can't work.

3.5.2.10 Call back event from Ethernet driver

【Prototype】

void eth_cbk(UH dev_num, UH opt, VP val)

【Operation】

Call back event from Ethernet driver

【Parameter】

UH	dev_num	Device number
UH	opt	Event type
VP	val	Event description

【Return value】

void

【Explanation】

This function is defined by network application. It is possible to control operation for asynchronous event or specific application operation by registering call back function to device configuration (T_NET_DEV gNET_DEV[]).

Event type and contents are showed below.

Event type	Event contents	Factor
EV_CBK_DEV_INIT	Always 0	When Ethernet driver is initialized
EV_CBK_DEV_LINK	Link down:0, Link up:1	When link status is changed

Caution Currently, link event cannot be detected.

3.5.2.11 Ethernet driver option setting - eth_ctl()

【Prototype】

ER eth_ctl(UH dev_num, UH opt, VP val)

【Operation】

Ethernet driver option setting

【Parameter】

UH	dev_num	Device number
UH	opt	Option type
VP	val	Setting value

【Return value】

ER	E_OK	Success
	E_PAR	Invalid parameter

【Explanation】

This function calls Ethernet driver or PHY driver setting function. Available options are showed below.

Option type	Description	Available value
ETH_OPT_PHY_MODE	PHY ability	same as set_phy_mode()
ETH_OPT_MCRX_MODE	Multicast address filter mode setting	same as set_mcast_filter_mode()
ETH_OPT_MCRX_ADR	Add multicast address filter	same as add_mcast_filter()
ETH_OPT_RAW_RXFNC	Ethernet frame receive report	same as eth_raw_rcv()
ETH_OPT_RAW_SNDDONE	Frame tranmit completaion report	same as eth_raw_snddone()

3.5.2.12 Get Ethernet driver option - eth_sts()

【Prototype】

ER eth_sts(UH dev_num, UH opt, VP val)

【Operation】

Get Ethernet driver option

【Parameter】

UH	dev_num	Device number
UH	opt	Option type
VP	val	Option contents

【Return value】

ER	E_OK	Success
	E_PAR	Invalid value

【Explanation】

This function calls Ethernet driver and PHY driver functions. Available option is below.

Option type	Option contents	Available value
ETH_OPT_PHY_MODE	Get PHY ability	same as get_phy_mode()

3.5.3 Configuration

Following configuration is written to DDR_ETH_CFG.h depends on purpose.

#define PHY_ADR0_EC

LAN1 PHY address for R-IN32M3-EC

#define PHY_ADR1_EC

LAN2 PHY address for R-IN32M3-EC

#define PHY_ADR0_CL

LAN1 PHY address for R-IN32M3-CL

#define PHY_ADR1_CL

LAN2 PHY address for R-IN32M3-CL

#define PROMISCUOUS_FILTER_MODE

Promiscuous filter mode. (0: receive all frames, 1: receive only self-station frame)

#define ETH_EARLY_TX_ENA

Early transmit mode. (0: disabled, 1: enabled)

If early transmit mode is enabled, it seems finish transmitting as soon as data was transmitted to FIFO in MAC controller.

#define ETH_TX_ASYNC

Non-blocking transmit mode. (0: disabled, 1: enabled)

If non-blocking mode is enabled, transmission is operated by send task of Ethernet drive.

#define USE_ETHSW

Ethernet switch is used or not. (0: not used, 1: used)

#define USE_ETHSW_MGTAG

Ethernet switch management tag is used or not. (0: not used, 1: used)

3.5.4 Cautions regarding Ethernet device driver

3.5.4.1 TCP/UDP hardware checksum function

Ethernet device driver uses hardware checksum function of R-IN32M3. Therefore, checksum calculation is not operated inside protocol stack.

T_NET_BUF structure member “flg” and global variable gNet[device number-1].flag can control whether checksum operation is used or not.

Following ensamples show how hardware checksum function is enabled.

Enables receive hardware checksum

```
T_NET_BUF *pkt;

pkt->flg    |= (HW_CS_RX_IPH4 | HW_CS_RX_DATA);
```

Enables transmit hardware checksum

```
T_NET      *net;

net = &gNET[eth_devnum-1];

/* set hardware checksum flag */
net->flag |= (HW_CS_TX_IPH4 | HW_CS_TX_DATA);
```

3.6 PHY driver<R>

Ethernet driver and PHY driver I/F are defined to global variable PHY_IO gPHY_IO[]. gPHY_IO[] is arrays to define some PHYs.

PHY driver API registered to this variable is called from Ethernet driver. Last element of gPHY_IO[] arrays must be set 0 to all of PHY_IO member and terminated. PHY_IO member is described below.

```
typedef struct phy_io {
    UW phy_id;
    UW phy_adr;
    ER (*phy_ini)(ID flg, UW id, UW adr);
    ER (*phy_ext)(void);
    ER (*phy_set_mode)(UW mode, UB nego);
    ER (*phy_get_mode)(UW *mode, UB *nego, UB *link);
}PHY_IO;
```

Member	Description
phy_id	PHY ID (ID number of LAN1~LAN4. If target is LAN1, this member is 1)
phy_adr	PHY address
phy_ini	Initialize function
phy_ext	Exit function
phy_set_mode	PHY ability setting function
phy_get_mode	PHY ability getting function

3.6.1 PHY driver API

3.6.1.1 Initialize PHY driver - phy_ini()

【Prototype】

ER phy_ini(ID flg, UW id, UW adr)

【Operation】

Initialize PHY driver

【Parameter】

ID	flg	Event flag ID
UW	id	PHY ID
UW	adr	PHY address

【Return value】

ER	E_OK	Success
	Others	Error when task start

【Explanation】

This function is called from Ethernet driver when eth_ini() function is executed. Event flag ID gives Ethernet driver link event. PHY ID gives event pattern when link event is noticed.

3.6.1.2 Exit PHY driver - phy_ext()

【Prototype】

ER phy_ext(void)

【Operation】

Exit PHY driver

【Parameter】

void

【Return value】

ER	E_OK	Success
	Others	Error when task finish

【Explanation】

This function is called from Ethernet driver when eth_cls() function is executed. This driver terminates link task.

3.6.1.3 PHY ability setting - phy_set_mode()

【Prototype】

ER phy_set_mode(UW mode, UB nego)

【Operation】

PHY ability setting

【Parameter】

UW	mode	Speed, duplex
UB	nego	Auto negotiation enabled(TRUE) / disabled(FALSE)

【Return value】

ER	E_OK	Finished

【Explanation】

This function is called from Ethernet driver when set_phy_mode() function is executed. Speed and duplex has the value referred from Table. 3.2. This value is different from Ethernet driver API set_phy_mode() parameter speed and duplex. Default value is PHY_AUTO_ABILITY when PHY driver has been initialized.

Table. 3.2 PHY ability setting

Settings	Description
PHY_10T_HD	10M/Half-duplex
PHY_10T_FD	10M/Full-duplex
PHY_100TX_HD	100M/Half-duplex
PHY_100TX_FD	100M/Full-duplex
PHY_1000T_HD	1G/Half-duplex
PHY_1000T_FD	1G /Full-duplex
PHY_AUTO_ABILITY	Auto selected

3.6.1.4 Get PHY ability - phy_get_mode()

【Prototype】

ER phy_get_mode(UW *mode, UB *nego, UB *link)

【Operation】

Get PHY ability

【Parameter】

UW*	mode	Speed and duplex
UB*	nego	Auto negotiation enabled / disabled
UB*	link	Link up / down

【Return value】

ER	E_OK	Finished

【Explanation】

This function is called from Ethernet driver when get_phy_mode() function is executed. Speed and duplex has the value referred from Table. 3.2. This value is different from Ethernet driver API set_phy_mode() parameter speed and duplex.

3.6.2 Link event notification

Rx task in Ethernet driver waits for receiving frame or changing link event state. The event shows link state change is set (set_flg()) by link task in PHY driver or interrupt handler.

The event flag ID (1st argument) in set_flg(id, ptn) has specified event flag ID when PHY driver starts. The event bit pattern (2nd argument) has logical OR “PHY_LINK_EVT” and PHY ID. PHY_LINK_EVT means link event, PHY ID is specified when PHY driver starts.

4. Network configuration

It's explained to configure TCP/IP protocol stack in this chapter.

4.1 Configuration of TCP/IP stack for R-IN32M3

TCP/IP stack parameters such as IP address and transmission buffer size can be configured by editing net_cfg.c.

4.1.1 Configuration list

The following is configurable parameter list.

The application can modify macro values defined as "#define CFG_XXX" (XXX is any), and cannot modify other macros or variables directly. Almost initial values are defined by "DEF_XXX" macro.

Configuration content [Unit]	Definition	Initial value	Minimum value	Maximum value
The number of data link devices	CFG_NET_DEV_MAX	1	1	2
The maximum number of all protocol sockets	CFG_NET_SOC_MAX	10	1	1000
The maximum number of TCP sockets	CFG_NET_TCP_MAX	5	0	1000
The number of ARP entries	CFG_NET_ARP_MAX	8	1	32
The number of multicast entries	CFG_NET_MGR_MAX	8	1	100
The number of IP reassembly queues	CFG_NET_IPR_MAX	2	1	16
Network buffer size [Byte]	CFG_NET_BUF_SZ	2048	768	2048
The number of network buffers	CFG_NET_BUF_CNT	16	2	100
Network buffer data offset (not allowed to change)	CFG_NET_BUF_OFFSET	42	42	42
MTU size	CFG_PATH_MTU	1500	576	1500
The number of ARP retry	CFG_ARP_RET_CNT	3	0	10
Timeout value for ARP retry [ms]	CFG_ARP_RET_TMO	1000	1	10000
Clear timeout of ARP cache [ms]	CFG_ARP_CLR_TMO	1200000	1000	3600000
TTL value of IP header	CFG_IP4_TTL	64	1	255
TOS value of IP header	CFG_IP4_TOS	0	0	255
Waiting time IP fragment packet [ms]	CFG_IP4_IPR_TMO	10000	1	60000
TTL value of multicast IP header	CFG_IP4_MCAST_TTL	1	1	255
Timeout value of IGMPv1 [ms]	CFG_IGMP_V1_TMO	40000	40000	120000
Timeout value of IGMP report [ms]	CFG_IGMP_REP_TMO	10000	10000	30000
MSS(TCP/IPv4) (MTU-IP header-TCP header)	CFG_TCP_MSS	1460	536	1460
MSS(TCP/IPv6) (MTU-IP header-TCP header)	CFG_TCP_MSS_IPV6	1440	516	1440
TCP/RTO (retry timeout) initial value [ms]	CFG_TCP_RTO_INI	3000	2000	3000
TCP/RTO (retry timeout) minimum value [ms]	CFG_TCP_RTO_MIN	500	200	500
TCP/RTO (retry timeout) maximum value [ms]	CFG_TCP_RTO_MAX	60000	30000	60000
TCP transmission buffer size [Byte]	CFG_TCP_SND_WND	1024	1024	8192
TCP reception buffer size [Byte]	CFG_TCP_RCV_WND	1024	1024	8192
Duplicate ACK number of retry beginning [reception count]	CFG_TCP_DUP_CNT	4	1	10
TCP/SYN transmission timeout [ms]	CFG_TCP_CON_TMO	75000	10000	75000

TCP/data transmission timeout [ms]	CFG_TCP_SND_TMO	64000	10000	64000
TCP/FIN transmission timeout [ms]	CFG_TCP_CLS_TMO	75000	10000	75000
TCP/2MSL timeout [ms]	CFG_TCP_CLW_TMO	20000	0	20000
TCP/delay ACK transmission period [ms]	CFG_TCP_ACK_TMO	200	100	1000
TCP/Keep-Alive notification count (in case of 0 Keep-Alive is disabled)	CFG_TCP_KPA_CNT	0	0	100
TCP/Keep-Alive notification period [ms]	CFG_TCP_KPA_INT	1000	1000	60000
Non-communication time until TCP/Keep-Alive starts [ms]	CFG_TCP_KPA_TMO	7200000	10000	14400000
The queuing number of reception packet	CFG_PKT_RCV_QUE	1	1	10
Waiting time ARP PROBE packet transmission [ms]	CFG_ARP_PRB_WAI	1000	1000	3000
The number of ARP PROBE packet transmission	CFG_ARP_PRB_NUM	3	1	6
ARP PROBE packet transmission period (minimum) [ms]	CFG_ARP_PRB_MIN	1000	100	1000
ARP PROBE packet transmission period (maximum) [ms]	CFG_ARP_PRB_MAX	2000	200	2000
Waiting time ARP ANNOUNCE packet [ms]	CFG_ARP_ANC_WAI	2000	200	2000
The number of ARP ANNOUNCE packet transmission	CFG_ARP_ANC_NUM	2	1	4
ARP ANNOUNCE packet transmission period [ms]	CFG_ARP_ANC_INT	2000	200	2000
Packet control flag (bit pattern) - Transmit ICMP Port Unreachable (bit0) - Ignore reception IP header checksum (bit1) - Ignore reception TCP header checksum (bit2) - Ignore reception UDP header checksum (bit3)	CFG_PKT_CTL_FLG	0	-	-

4.1.2 IP address

Set up IP address. Because every network device needs an IP address, please register CFG_NET_DEV_MAX part for IP address.

The following is the example for set up of IP address:192.168.1.10, gateway：192.168.1.1, subnet mask: 255.255.255.0.

```
T_NET_ADR gNET_ADR[] = {
  {   /*   for Device 1   */
     0x0,              /* Must be 0 */
     0x0,              /* Must be 0 */
     0xC0A8000A,  /* Setting IP address 192.168.1.10     */
     0xC0A80001,  /* Gateway 192.168.1.1       */
     0xFFFFFF00,  /* Subnet mask 255.255.255.0 */
  }
};
```

4.1.3 Device Driver

Set device driver. Please register CFG_NET_DEV_MAX part for device driver.

```
T_NET_DEV gNET_DEV[]   =   {
   { ..}
}
```

Please refer to 3.2 Network device driver for more details.

4.1.4 Information table of protocol stack

Set global variable of protocol stack as below.

```
const VP net_inftbl[] = {
0,                          /* Necessarily specify 0*/
(VP)gNET_SOC,          /* Set NULL in case of not using socket */
(VP)gNET_TCP,          /* Set NULL in case of not using socket*/
(VP)gNET_IPR,          /* Set NULL in case of not using IP reassembly function */
(VP)gNET_MGR,          /* Set NULL in case of not using IGMP*/
(VP)gTCP_SND_BUF,    /* Set NULLin case of not using TCP socket*/
};
```

5. Description of application programming interface

5.1 Initialization of protocol stack

To use TCP/IP protocol stack, the initialization of protocol stack and initialization of network device are needed. Basically initialization is as follows:

Example of initialization code

```
/* Initialization of protocol stack */
        ercd    =       net_ini();
if (ercd != E_OK) {
          return ercd;
        }
/* Network device initialization (device number N) */
        ercd    =       net_dev_ini(N);
If (ercd != E_OK) {
return ercd;
}
```

5.2 Network Interface API

net_ini	Initialization of TCP/IP protocol stack

【Format】

```
ER ercd = net_ini(void);
```

【Parameter】

None

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

<0	Initialization failure

【Explanation】

Initialize the resource to be used by protocol stack. Kernel objects (tasks, memory pools, semaphores) to be used by protocol stack are also created and initialized simultaneously. Besides, the initial value is set in global variable used in protocol stack.

In case of using protocol stack, it needs to issue this API prior to any other API.

net_cfg	Parameter setting of network interface

【Format】

ER ercd = net_cfg(UH num, UH opt, VP val);

【Parameter】

UH	num	Device number
UH	opt	Parameter code
VP	val	Value to set

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_NOSPT	Wrong parameter code
E_ID	Wrong parameter code
E_NOMEM	Too many multicast table

【Explanation】

Set up forIP address and subnet mask, broadcast address, multicast and others.

Setting sample
net_cfg(1, NET_BCAST_RCV, (VP)1); /* enable broadcast reception */

Parameter code	Data type	Meaning
NET_IP4_CFG	T_NET_ADR	Set IP address, subnet mask, gateway. Please hand pointer of T_NET_ADR to val.
NET_IP4_TTL	UB	Set TTL (Time to Live) Default is set 64.
NET_BCAST_RCV	UB	Set whether to receive broadcast or not. Set 1 to receive and 0 to not receive.
NET_MCAST_JOIN	UW	Register IP address of multicast group to join
NET_MCAST_DROP	UW	Set IP address of multicast group to drop
NET_MCAST_TTL	UB	Set TTL to be used in multicast transmission
NET_ACD_CBK	Callback function pointer	In this field, set the callback function to notify that it has detected an IP address conflict during operation. Notification feature is enabled by this setting of conflict detection.

net_ref	Reference parameter for network interface

【Format】

ER ercd = net_ref(UH num, UH opt, VP val);

【Parameter】

UH	num	Device number
UH	opt	Parameter code
VP	val	Pointer to buffer of the value to get

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_NOSPT	Wrong parameter code
E_ID	Wrong device number

【Explanation】

Verify the basic setting of IP address and subnet mask, broadcast address and others.

Setting sample

```
UB bcast;
net_ref(1, NET_BCAST_RCV, (VP)&bcast);   /* reception status of broadcast */
```

Parameter code	Data type	Meaning
NET_IP4_CFG	T_NET_ADR	Get IP address, subnet mask, gate-way. Please hand pointer of T_NET_ADR to val
NET_IP4_TTL	UB	Get TTL (Time to Live).
NET_BCAST_RCV	UB	Get the receive status of broadcast
NET_MCAST_TTL	UB	Get TTL broadcast transmission

net_acd	Detection IP Address Confliction

【API】

ER ercd = net_acd(UH dev_num, T_NET_ACD *acd);

【Parameter】		
UH	num	Deviec Number
T_NET_ACD	*acd	Address Conflict Information

【Return Value】		
ER	ercd	Success (E_OK) or Error Code

【Error Code】	
E_ID	Illegal Device Number
E_PAR	Illegal Parameter
E_OBJ	Call Duplicate or Call host IP undefined
E_TMOU	Time out ARP transmit
E_SYS	Detect IP address conflict
E_OK	No Detect IP address conflict

【DESCRIPTION】

This API is done in the device specified by dev_num, IP address conflict detection.

If it detects a conflict for the IP address, MAC address of the other party is stored in the conflict information of the argument.

If you want to detect conflicts in asynchronous IP address separately, you will need to register a callback function () API net_cfg with this API.

Note : Function is recommended that a maximum of about 10 seconds, call a dedicated task to attempt the detection of address conflicts.

net_cbk	Callback IP address conflict detected.

【API】

ER acd_cbk(T_NET_ACD* acd);

【Parameter】

T_NET_ACD	*acd	Address Conflict Information

【Return Value】

ER	ercd	Success (E_OK) or Error Code

【DESCRIPTION】

This function is called when it detects an IP address conflict during operation. The conflict is stored what conflict information of the argument MAC address of the host that.

If the IP address for the conflict, continue to use the IP address in the host itself, please return the E_OK. Otherwise, please return the E_SYS.

Called on the task that received the ARP packet (task received Ethernet driver) callback function. The callback function should therefore be terminated immediately. There is no callback function that is called (running () net_acd) detection in IP address.□Use Casee

```
/* Callback function at the time of detecting address conflicts */
ER acd_detect(T_NET_ACD * acd)
{
	return E_OK;
}

/* Network Initialize Function */
ER net_setup(void)
{
	ER ercd;
	T_NET_ACD acd;

	ercd = net_ini();
	if (ercd != E_OK) {
		return ercd;
	}
	ercd = net_dev_ini(ID_DEVNUM_ETHER);
	if (ercd != E_OK) {
		return ercd;
	}

	/* Detect IP Address Conflict */
	ercd = net_acd(ID_DEVNUM_ETHER, &acd);
	if (ercd == E_OK) {
		/* No Information IP Address conflict */
		/* Callback function at the time of detecting IP address conflicts */
		net_cfg(ID_DEVNUM_ETHER, NET_ACD_CBK, (VP)acd_detect);
	}
	else if (ercd == E_SYS) {
		/* MAC address is conflict a host of acd.mac IP address */
	} else {
		/* Failed to detect IP address conflict */
	}
	return ercd;
}
```

5.3 Network Device Control API

The Network Device Control API provides interface to access unifiedly from application to device driver. For each device, it specifies a device number to access this API. Device number is the specific number to identify the device.

net_dev_ini	Network device initialization

【Format】

ER ercd = net_dev_ini(UH dev_num);

【Parameter】

UH	dev_num	Device number

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

<0	Initialization failure

【Explanation】

Use dev_num to initialize a specific device. In fact, net_dev_ini uses dev_ini of driver device to initialize the device. If it completes normally, it can handle the packet through that network device.

net_dev_cls	Release network device

【Format】

```
ER ercd = net_dev_cls(UH dev_num);
```

【Parameter】

UH	dev_num	Device number

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

<0	Failure

【Explanation】

Release specific device by using dev_num. In fact, net_dev_cls will release device by using dev_cls of device driver.

net_dev_ctl	Network device control

【Format】

```
ER ercd = net_dev_ctl(UH dev_num, UH opt, VP val);
```

【Parameter】

UH	dev_num	Device number
UH	opt	Control code
VP	val	Value to set

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

<0	Failure

【Explanation】

Control the specific device by using dev_num. Because net_dev_ctl only calls dev_ctl of device driver, the actual actions depend much on integration of driver device.

net_dev_sts	Acquire the status of network device

【Format】

ER ercd = net_dev_sts(UH dev_num, UH opt, VP val);

【Parameter】

UH	dev_num	Device number
UH	opt	Status code
VP	val	Getting value

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

<0	Failure

【Explanation】

Acquire the status of specific device by using dev_num. Because net_dev_sts only calls dev_ref of device driver, the detailed action depends on integration of device driver.

5.4 Socket API (uNet3 compatible)

Application uses socket API to exchange TCP/UDP data with remote host.

When creating socket or connecting, it's necessary to use device number to specify network device to connect. In case specify device number 0, it means that "Don't specify device", the interface selection action between socket and network device is different depending on transmission or reception. Besides, when creating socket, if it specify device number beside 0, it don't need to specify device number when connecting.

For example, in the system is constructed by N network devices (N is more than 2) with the using socket APIs, show in the below it.

	Device number when creating (※1)	**Device number when connecting (※2)**	**Device in use**
Socket transmission action con_soc() of snd_soc() and TCP client (SYN transmission)	0	0	Device number 1(top)
	0	N	Device number N
	N	ANY	Device number N
Socket reception action con_soc() of rcv_soc() and TCP server (SYN reception)	0	0	Notified device (※3)
	0	N	Device number N
	N	ANY	Device number N

※1 In case of R-IN32M3 TCP/IP stack, when adding socket by the configurator, we specify network device. In case of Standard,
it specify by host->num argument of con_soc() API.

※2 Specify by host->num argument of con_soc() API. In case of receiving through UDP socket, do not need to call con_soc() API.

※3 The socket which does not specify device number even when creating or connecting socket, if port number and protocol are matched, it can receive packet from any device. The socket in this case uses the device notified packet
in subsequent operation.

cre_soc	Socket generation

【Format】

ER ercd = cre_soc(UB proto, T_NODE *host);

【Parameter】

UH	proto	Protocol type
T_NODE	*host	Information of local host

【Return value】

ER	ercd	ID of generated socket (>0) or error code

【Error code】

E_ID	Unable to generate socket (exceed maximum number of socket)
E_PAR	‘host’ is wrong
E_NOSPT	‘proto’ is wrong

【T_NODE】

Specify local port number and device interface to use.

UH	port	Port number	Port number of local host. Specify the value from 1 to 65535 or PORT_ANY. In case that PORT_ANY is specified, it will determine port number by protocol stack.
UH	ver	IP version	Specify 0 (use IP_VER4)
UB	num	Device number	Specify device number of the device it want to use
UW	ipa	IP address	Specify 0 (use local IP address)

【proto】

Protocol type of socket to create

IP_PROTO_TCP	TCP socket
IP_PROTO_UDP	UDP socket

【Explanation】

This API creates the socket of specified protocol.

Example of creating TCP socket

```
T_NODE host;
host.num = 1;
host.port = 7;
host.ver = IP_VER4;
host.ipa = INADDR_ANY;
cre_soc(IP_PROTO_TCP, &host);
```

del_soc	Delete socket

【Format】

ER ercd = del_soc(UH sid);

【Parameter】

UH	sid	ID is used to identify socket

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_ID	Wrong ID number
E_NOEXS	Socket does not exist (Socket has not been created yet)
E_OBJ	Status of socket is wrong

【Explanation】

This API deletes the specified ID socket. When delete TCP socket, please call cls_soc() in advance and close the socket.

con_soc	Socket connection

【Format】

ER ercd = con_soc(UH sid, T_NODE *host, UB con_flg) ;

【Parameter】

UH	sid	ID is used to identify socket
T_NODE	*host	Information of remote host
UB	con_fig	Connection mode

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_ID	Wrong ID number
E_NOEXS	Socket does not exist (Socket has not been created yet)
E_PAR	Host or con_flg is wrong
E_OBJ	Socket status is wrong (for example, calling this API for the socket which has already connected)
E_TMOUT	Connection process is out of time
E_WBLK	Processed by non-blocking mode
E_CLS	Refuse the connection from remote host
E_RLWAI	Connection process is interrupted
E_QOVR	con_soc() is already executing

【T_NODE】

Specify remote host and device interface to use.

UH	port	Port number	Port number of remote host (from 1 to 65535)
UH	ver	IP version	Specify 0
UB	num	Device number	Device number of the device that wants to use
UW	ipa	IP address	IP address of remote host

【con_fig】

Specify the waiting for connection (server) or the active connection (client).

Usually specify 0 for UDP socket.

SOC_CLI	Connect to remote host (active connection)
SOC_SER	Wait for connection (passive connection)

【Explanation】

This API has different behavior depending on using protocol.

In the course of TCP, establish the connection to remote host, in case of UDP, associate the socket with the destination of data transmission.

An example for the connection of TCP server socket
T_NODE remote = {0}; /* clear by 0 */ con_soc(ID, &remote, SOC_SER);

An example for the connection of TCP client socket

T_NODE remote;
remote.port = 100; /* Port number of remote host */
remote.ver = IP_VER4;
remote.num = 1; /*Specify device number to use */
remote.ipa = ip_aton(“192.168.11.1”); /*IP address of remote host */
con_soc(ID, &remote, SOC_CLI);

cls_soc	Socket disconnetion	

【Format】

ER ercd = cls_soc(UH sid, UB cls_flg);

【Parameter】

UH	sid	ID is used to identify socket
UB	cls_fig	Disconnetion mode

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_ID	Wrong ID number
E_NOEXS	Socket does not exist (Socket has not been created yet)
E_PAR	‘cls_flg is wrong
E_OBJ	Socket status is wrong (Such as when calling this API in the status of disconnection)
E_TMOUT	Disconnection process is out of time
E_WBLK	Processed by non-blocking mode
E_CLS	Forced termination of the connection from remote host
E_RLWAI	Disconnection process is interrupted
E_QOVR	cls_soc() is executing already

【cls_flg】

This parameter is only valid for TCP socket

SOC_TCP_CLS	Disconnect socket (End the connection)
SOC_TCP_SHT	Disable transmission process only. Reception is possible. (In case that want to stop the connection completely after using SOC_TCP_SHT to discontinue the transmission process only, it need to use SOC_TCP_CLS to disconnect completely.)

【Explanation】

This API has different behavior depending on using protocol.

In case of TCP, stop the connection to remote host, in case of UDP, clear the information of the destination or the source of data associated with socket. (After that, it cannot send UDP data).

cfg_soc	Set parameter of socket

【Format】

ER ercd = cfg_soc(UH sid, UB code, VP val) ;

【Parameter】

UH	sid	ID is used to identify socket
UB	code	Parameter code
VP	val	Value to set

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_ID	Wrong ID number
E_NOEXS	Socket does not exist (Socket has not been created yet)
E_NOSPT	Wrong parameter code
E_PAR	Wrong parameter value
E_OBJ	Status of socket is wrong

【Explanation】

This API can set parameter as below. Please cast and then hand the setting value to VP type.

Example of setting
UB ttl = 32; cfg_soc(ID, SOC_IP_TTL, (VP)ttl);

Parameter code	Data type	Meaning
SOC_TMO_CON	TMO	Calling timeout of con_soc
SOC_TMO_CLS	TMO	Calling timeout of cls_soc
SOC_TMO_SND	TMO	Calling timeout of snd_soc
SOC_TMO_RCV	TMO	Calling timeout of rcv_soc
SOC_IP_TTL	UB	Set TTL of IP header (Time to Live)
SOC_IP_TOS	UB	Set TOS of IP header (Type of Server)
SOC_CBK_HND	Pointer for function	Register callback function
SOC_CBK_FLG	UH	Set bit pattern of callback event flag (Value to set is as below)
SOC_PRT_LOCAL	UH	Change Local Port Number

Callback event flag bit	Meaning
EV_SOC_CON	Set con_soc() in non-blocking mode (only TCP socket)
EV_SOC_CLS	Set cls_soc() in non-blocking mode (only TCP socket)
EV_SOC_SND	Set snd_soc() in non-blocking mode
EV_SOC_RCV	Set rcv_soc() in non-blocking mode

Regarding callback event flag bit, it can set a multiple bit. In case of setting it multiple, set by OR. An example of setting is as below.

Ex: ercd = cfg_soc(ID socket, SOC_CBK_FLG, (VP)(EV_SOC_CON|EV_SOC_SND|EV_SOC_RCV|EV_SOC_CLS));

Socket event set in non-blocking disables socket timeout of that event.

When enable callback event flag bit, it is necessary to register callback function in SOC_CBK_HND. Regarding callback function, please refer to the following.

soc_cbt	Callback function

【Format】

UW soc_cbt(UH sid, UH event, ER ercd);

【Parameter】

UH	sid	ID is used to identify socket
UH	event	Callback event flag bit
ER	ercd	Error code

This callback function is called out from TCP/IP stack. However, in case of execution API socket of non-blocking mode, if API process is necessary to enter the waiting sate, it will return E_WBLK value without enter. This time, it will be notified from TCP/IP stack that the process of callback function has completed.

Call back event flag bit (event)	Error code (ercd)	Meaning
EV_SOC_CON	E_OK	con_soc() process completes normally
	< 0	con_soc() process completes with error. Regarding error content of this time, please refer to error code of con_soc().
EV_SOC_CLS	E_OK	cls_soc() process completes normally
	< 0	cls_soc() process complete with error. Regarding error content of this time, please refer to error code of cls_soc().
EV_SOC_SND	> 0	UDP socket： snd_soc()process completes normally TCP socket： In case of TCP transmission buffer is available, it will show the available size by ‘ercd’ value. Again, snd_soc() is called and then it can copy transmission data into TCP transmission buffer.
	<= 0	snd_soc() process completes normally. Regarding error content of this time, please refer to error code of snd_soc().
EV_SOC_RCV	> 0	UDP socket： There is receipt data in UDP socket. Shows receipt data size by ‘ercd’ value. Again, it can call rcv_soc() to receive data. TCP socket： There exists receipt data in TCP socket. Shows receipt data size by ‘ercd’ value. Again, it can call rcv_soc() to receive data.
	<= 0	rcv_soc() process completes normally. Regarding error content of this time, please refer to error code of rcv_soc().

※Prohibit to call all API functions of R-IN32M3 TCP/IP stack from callback function. (Please think callback unction the same as interrupting handler and use it).

ref_soc	Refer parameter of socket

【Format】

ER ercd = ref_soc(UH sid, UB code, VP val) ;

【Parameter】		
UH	sid	ID is used to identify socket
UB	code	Parameter code
VP	val	Pointer for buffer of the value to get

【Return value】		
ER	ercd	Successful completion (E_OK) or error code

【Error code】	
E_ID	Wrong ID number
E_NOEXS	Socket does not exist (socket has not been created yet)
E_NOSPT	Wrong parameter code
E_PAR	Wrong parameter value (in case that val is NULL)
E_OBJ	Socket status is wrong (Cannot refer to socket)

【Explanation】

Refer the parameters as below. Please cast and then hand the setting value to VP type.

Example of getting remote host information
T_NODE remote; ref_soc(ID, SOC_IP_REMOTE, (VP)&remote);

Parameter code	Data type	Meaning
SOC_TMO_CON	TMO	Calling timeout of con_soc
SOC_TMO_CLS	TMO	Calling timeout of cls_soc
SOC_TMO_SND	TMO	Calling timeout of snd_soc
SOC_TMO_RCV	TMO	Calling timeout of rcv_soc
SOC_IP_LOCAL	T_NODE	Getting Port number and IP address of local host
SOC_IP_REMOTE	T_NODE	Getting port number and IP address of remote host
SOC_IP_TTL	UB	Getting TTL (Time to Live)
SOC_IP_TOS	UB	Getting TOS (Type Of Service)
SOC_RCV_PKT_INF	T_RCV_PKT_INF	Getting newest information of packet received by socket (in case of TCP, it's unable to get)
SOC_PRT_LOCAL	UH	Reference Local Port Number

For the socket having both multicast address and unicast address, to know IP address of the last received packet, please refer to the below.

Example of getting received IP address

T_RCV_PKT_INF rcv_pkt_inf;
ref_soc(ID, SOC_RCV_PKT_INF, (VP)&rcv_pkt_inf);
if(rcv_pkt_inf.dst_ipa == MULTICASTADDRESS) {
  /* received by multicast address */
}

abt_soc	Abort the socket process

【Format】

ER ercd = abt_soc(UH sid, UB code);

【Parameter】		
UH	sid	ID is used to identify socket
UB	code	Control code

【Return value】		
ER	ercd	Successful completion (E_OK) or error code

【Error code】	
E_ID	Wrong ID number
E_NOEXS	Socket does not exist (socket has not been created yet)
E_NOSPT	Wrong control code
E_OBJ	Socket status is wrong

【Explanation】

This API can cancel waiting status of con_soc, cls_soc, snd_soc, rcv_soc. Cancelled API returns E_RLWAI .

Control code	Meaning
SOC_ABT_CON	Discontinuation of con_soc() process
SOC_ABT_CLS	Discontinuation of cls_soc() process
SOC_ABT_SND	Discontinuation of snd_soc() process
SOC_ABT_RCV	Discontinuation of rcv_soc() process
SOC_ABT_ALL	Process discontinuation of all sockets

snd_soc	Data transmission

【Format】

ER ercd = snd_soc(UH sid, VP data, UH len);

【Parameter】		
UH	sid	ID is used to identify socket
VP	data	Pointer to the transmit data
UH	len	Size of the transmit data

【Return value】		
ER	ercd	Actual transmitted data size (>0) or error code

【Error code】	
E_ID	Wrong ID number
E_NOEXS	Socket does not exist (socket has not been created yet)
E_PAR	Wrong transmitted data or data size for transmission is not specified.
E_OBJ	Socket status is wrong
E_TMOUT	Transmission process is out of time
E_WBLK	Processed by non-blocking mode
E_CLS	Forced termination of the connection from remote host
E_RLWAI	Transmission process is interrupted
E_NOMEM	Memory is not enough
E_QOVR	snd_soc() is executing already

【Explanation】

This API transmits data to remote host. When the process succeeds, it will return the actual transmitted data size. Besides that case, it will return error code.

In case of TCP socket, this API will copy data into protocol stack inside, and return that copied size. (Returned data size is less than len specified by argument) . Please refer to “3.1.4 TCP module” for details.

In case of UDP socket, data will be transmitted to network and return that transmitted size. Please refer to “3.1.3 UDP module” for details.

rcv_soc	Data reception

【Format】

ER ercd = rcv_soc(UH sid, VP data, UH len);

【Parameter】

UH	sid	ID is used to identify socket
VP	data	Pointer to receipt data
UH	len	Receipt data size

【Return value】

ER	ercd	Actual received data size (>0) or error code

【Error code】

E_ID	Wrong ID number
E_NOEXS	Socket does not exist (socket has not been created yet)
E_PAR	Wrong receipt data or receipt data size is not specified.
E_OBJ	Socket status is wrong
E_TMOUT	Receipt process timed out
E_WBLK	Processed by non-blocking mode
E_CLS	Forced termination of the connection from remote host
E_RLWAI	Reception process is interrupted
E_QOVR	rcv_soc() is executing already
0	The connection is disconnected

【Explanation】

This API receive data which is sent from remote host.

In case of TCP, the maximum receivable size to receive is “Reception buffer size” specified by the configurator. Please refer to “3.1.4 TCP module” for details.

In case of UDP, the maximum receivable size to receive is 1472 bytes (MTU default － IP header size － UDP header size). Please refer to “3.1.3 UDP module” for details.

5.5 Socket API (BSD compatible) <R>

TCP/IP stack for R-IN32M3 has the socket API for the BSD interface too. Thus, it is possible to easily divert the existing network applications using BSD sockets API.

5.5.1 Module overview

5.5.1.1 Position of the POSIX specification

TCP/IP stack for R-IN32M3 is supported the socket API which is equivalent to the 4.4BSD-Lite. For supported API list, please refer the section **5.5.3 API list**.

5.5.1.2 The difference to uNet3 socket API

In addition to the POSIX-compliant sockets API, also provides the features that did not combine in µNet3 socket.

- Multiple call of socket API
- select() function
- Loop back address
- Multicast group with socket unit
- Listen queue of TCP socket
- Socket error

5.5.1.3 Compatibility of symbol name

The APIs, structures, and macros are added the unique prefix "unet3_" in order to avoid a symbol collision by the compiler environment.

By including sys/socket.h, the symbol name of the POSIX standard, which is used in application, be replaced with to these symbols with unique prefix. So application source codes based on BSD socket can be run as is.

The notation in this document has been using the POSIX standard symbol, because of considering the readability.

5.5.2 Module structures

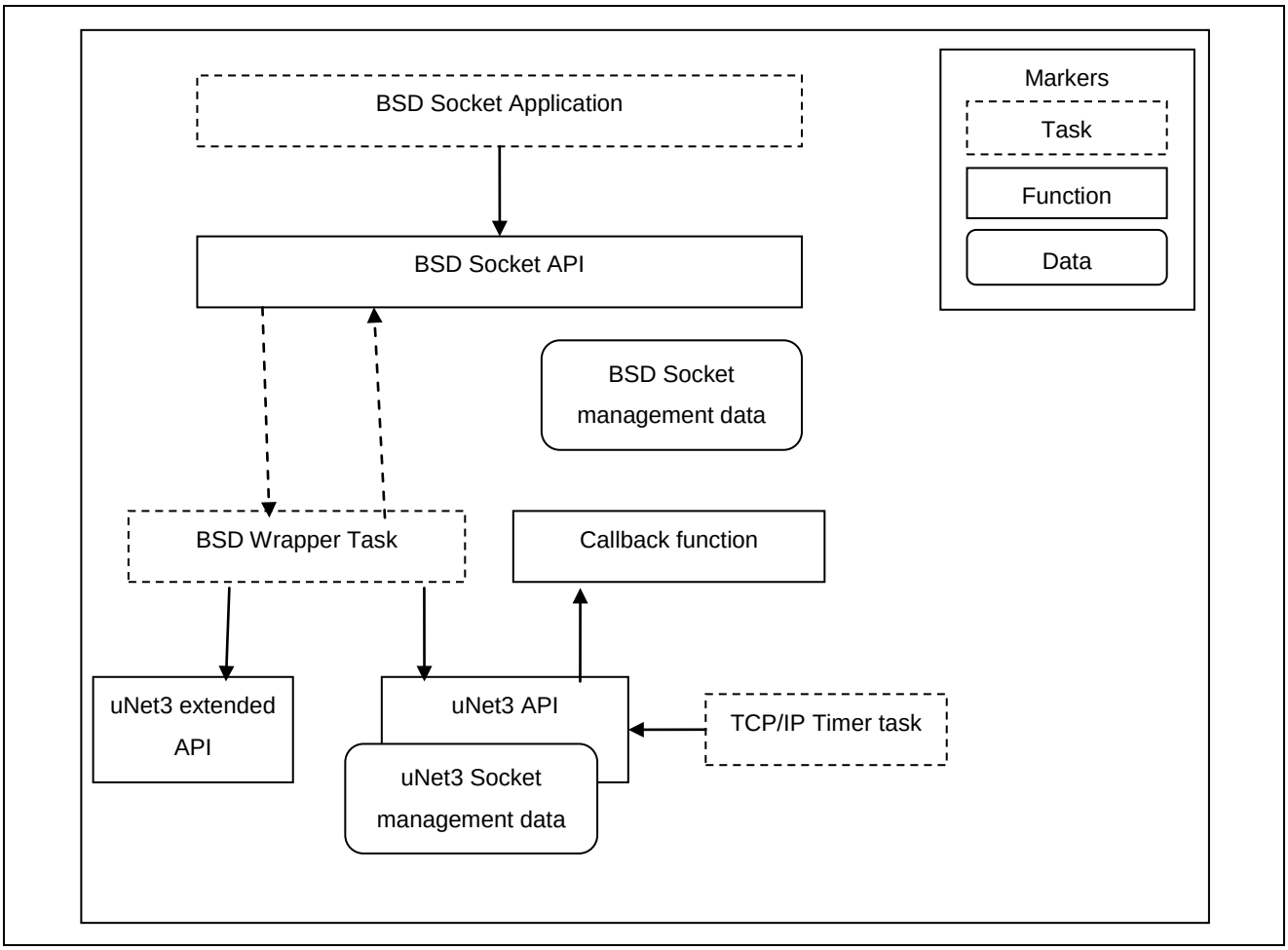


Fig. 5.1 Module structure for BSD socket

5.5.3 API list

Table 5.1 API list

API	Function	Include header
unet3_bsd_init	Initialize the TCP/IP and BSD stack for R-IN32M3	“sys/socket.h”
get_errno	Get the errno of each task	“sys/errno.h”
socket	Create an end point for communication	“sys/socket.h”
bind	Put a name for socket	“sys/socket.h”
listen	Wait the connection on the socket	“sys/socket.h”
accept	Accept connection to the socket	“sys/socket.h”
connect	Connect to the socket	“sys/socket.h”
send	Send message to the socket	“sys/socket.h”
sendto	Send message to the socket	“sys/socket.h”
recv	Receive message from the socket	“sys/socket.h”
recvfrom	Receive message from the socket	“sys/socket.h”
shutdown	Close the part of the full-duplex connection	“sys/socket.h”
close	Close the descriptor (socket)	“sys/ unistd.h”
select	Multiplexing of synchronous I / O	“sys/ select.h”
getsockname	Get the name of the socket	“sys/socket.h”
getpeername	Get the name of the peer socket	“sys/socket.h”
getsockopt	Get the socket options	“sys/socket.h”
setsockopt	Set the socket options	“sys/socket.h”
ioctl	Control the device (socket)	“sys/ioctl.h”
inet_addr	Internet address manipulation routines	“arpa/inet.h”
inet_aton	Internet address manipulation routines	“arpa/inet.h”
inet_ntoa	Internet address manipulation routines	“arpa/inet.h”
if_nametoindex	Mapping name and index of the network interface	“net/if.h”
if_indextoname	Mapping name and index of the network interface	“net/if.h”
rresvport	Get the socket which is bound to port	“sys/unistd.h”
getifaddrs	Get the address of the interface	“sys/types.h”
freeifaddrs	Release the interface information	“sys/types.h”

5.5.4 Detail for each API

5.5.4.1 unet3_bsd_init

Please refer the section 5.5.7.6 Initialization

5.5.4.2 get_errno

Please refer the section 5.5.6.3 Error handling

5.5.4.3 socket (Create an end point for communication)

【Format】

```
#include “sys/socket.h”
int socket(int domain, int type, int protocol);
```

【Parameter】

int	domain	Domain
int	type	Communication type
int	protocol	Protocol

【Return value】

int	Generated socket FD. On error, -1.

【errno】

ENOMEM	Over the generation possible number of sockets Message buffer is depleted
EINVAL	Parameter is incorrect

【Explanation】

- The domain can be specified only AF_INET or AF_INET6.
- The communication type can be specified only SOCK_STREAM or SOCK_DGRAM.
- Protocol parameter is not used, so any value is possible.
- The number of sockets (sum of for TCP and UDP) that can be generated at the same time is the value defined by “#define CFG_NET_SOC_MAX”.
- The number of TCP sockets that can be generated at the same time is the value defined by “#define CFG_NET_ TCP _MAX”.
- The local port of socket cannot be set to 0, unlike the POSIX specification. Therefore the socket immediately after generation is assigned the temporary local port number.

5.5.4.4 bind (Put a name for the socket)

【Format】

```
#include “sys/socket.h”
int bind(int sockfd, const struct sockaddr *addr, unsigned int addrlen);
```

【Parameter】

int	sockfd	Socket FD
const struct sockaddr *	addr	Local address
unsigned int	addrlen	Local address length

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be bound
EAFNOSUPPORT	Unsupported address family
EADDRINUSE	Address is already in use
EADDRNOTAVAIL	Address is not available

【Explanation】

- Local address should be set as struct sockaddr_in type.
- IP address (IPv4) for the local address can be specified only the address which is set to device or INADDR_ANY (unspecified).
- If user sets the PORT_ANY (0) to the port number of the local address, a port number is assigned in the protocol stack.
- The local address length can be specified only sizeof(struct sockaddr_in) (=16).
- The member “sin_len” with struct sockaddr_in type is not used, so any value is possible.
- To start the receive operation, user needs to run the bind() function in advance with specifying the socket of the target. In here, the receive operation means a standby connection of TCP (listen()) and the reception of UDP packet (recv (), recvfrom ()).
- User can bind() to wellknown port (1-1023) also.

5.5.4.5 listen (Wait the connection on the socket)

【Format】

```
#include “sys/socket.h”
int listen(int sockfd, int backlog);
```

【Parameter】

int	sockfd	Socket FD
int	backlog	Back log

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be listened
EPROTONOSUPPORT	Unsupported protocol (not TCP)

【Explanation】

- TCP socket becomes to the state for waiting connection.
- The socket FD can be specified only the socket FD of TCP.
- The maximum number for back log is #define CFG_NET_TCP_MAX - 1.

5.5.4.6 accept (Accept connection to the socket)

【Format】

```
#include “sys/socket.h”
int accept(int sockfd, struct sockaddr *addr, unsigned int *addrlen);
```

【Parameter】

int	sockfd	Socket FD
struct sockaddr *	addr	Remote address (output)
unsigned int *	addrlen	Remote address length (output)

【Return value】

int	The connected socket FD. On error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be bound
EAGAIN	The socket is not connected. (During asynchronous execution)
ETIMEDOUT	Timeout (if the timeout is set)

【Explanation】

- The socket FD can be specified only the socket FD of TCP that listen() function had been successful.
- The remote address is set as struct sockaddr_in* type.
- If there are not any the connected socket, the accept() function blocks the processes until it is connected from remote.

5.5.4.7 connect (Connect to the socket)

【Format】

```
#include “sys/socket.h”
int connect(int sockfd, const struct sockaddr *addr, unsigned int addrlen);
```

【Parameter】

int	sockfd	Socket FD
const struct sockaddr *	addr	Remote address
unsigned int	addrlen	Remote address length

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be connected
ECONNREFUSED	The connection was refused
EAFNOSUPPORT	Unsupported address family
EISCONN	Already connected.
	Socket is under listen.
EALREADY	Already connected.
EAGAIN	The socket is under connection. (During asynchronous execution)
ETIMEDOUT	Timeout (if the timeout is set)

【Explanation】

- The behavior or operation for connect() is different by the socket FD protocol or send/receive operation.
- In the case of the connection of TCP socket, SYN is sent to the remote address and try to do communication..
- In the case of the sending of UDP socket, the remote address is set as the destination address. However if the different destination address with sendto() is specified, the destination address for sendto() is used.
- If you a remote address family (sa_family) are specified to AF_UNSPEC, these settings will be cleared.
- Unlike the POSIX specification, there is no filtering function by remote address for the receiving operation of the UDP socket.
- Unlike the POSIX specification, in the connect() for TCP socket with the asynchronous setting, user cannot issue the connect() again after the connection is completed. For example after confirmed EAGAIN for connect() and be guaranteed the writable status by select(), sending/receiving data becomes possible, because TCP session has been established at that point in time.

5.5.4.8 send (Send message to the socket)

【Format】

```
#include “sys/socket.h”
int send(int sockfd, const void *buf, unsigned int len, int flags);
```

【Parameter】

int	sockfd	Socket FD
const void *	buf	Address for sending data
unsigned int	len	Length for sending data
int	flags	Flag

【Return value】

int	Byte number which is sent. On error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
	Cannot get the network buffer corresponding to “len”
EBADF	Socked FD cannot be sent
EDESTADDRREQ	Unsetting the address (UDP socket)
ENOTCONN	Not be connected (TCP socket)
EAGAIN	The socket is under sending. (During asynchronous execution)
ETIMEDOUT	Timeout (if the timeout is set)

【Explanation】

- The length for sending data can be specified the value from 1 to 65535.
- The flag is not used, so any value is possible.
- The sending 0 byte UDP data cannot be sent, unlike the POSIX specification.

5.5.4.9 sendto (Send message to the socket)

【Format】

```
#include “sys/socket.h”
int sendto(int sockfd, const void *buf, unsigned int len, int flags, const struct sockaddr *dest_addr, unsigned int addrlen);
```

【Parameter】

int	sockfd	Socket FD
const void *	buf	Address for sending data
unsigned int	len	Length for sending data
int	flags	Flag
const struct sockaddr *	dest_addr	The destination address
unsigned int	addrlen	Length of the destination address

【Return value】

int	Byte number which is sent. On error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
	Cannot get the network buffer corresponding to “len”
EBADF	Socked FD cannot be sent to
EDESTADDRREQ	Unsetting the address (UDP socket)
ENOTCONN	Not be connected (TCP socket)
EAGAIN	The socket is under sending. (During asynchronous execution)
ETIMEDOUT	Timeout (if the timeout is set)

【Explanation】

- The length for sending data can be specified the value from 1 to 65535.
- The flag is not used, so any value is possible.
- In the case of TCP socket, the destination address and length of it is not used
- The sending 0 byte UDP data cannot be sent, unlike the POSIX specification.

5.5.4.10 recv (Receive message from the socket)

【Format】

```
#include “sys/socket.h”
int recv(int sockfd, void *buf, unsigned int len, int flags);
```

【Parameter】

int	sockfd	Socket FD
void *	buf	Address for receiving buffer
unsigned int	len	Length for receiving buffer
int	flags	Flag

【Return value】

int	Byte number which is received (included 0). On error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
	Cannot get the network buffer corresponding to “len”
EBADF	Socked FD cannot be received
ENOTCONN	Not be connected (TCP socket)
EAGAIN	The packet had not received yet. (During asynchronous execution)
ETIMEDOUT	Timeout (if the timeout is set)

【Explanation】

- The length for received buffer can be specified the value from 1 to 65535.
- The flag is not used, so any value is possible.
- If there are not any received packets, the recv() function blocks the processes until reception of packet.
- If not yet connected to the remote as TCP socket, recv () will result in an error.
- If in disconnected condition from remote with TCP socket, recv() returns 0.

5.5.4.11 recvfrom (Receive message from the socket)

【Format】

```
#include “sys/socket.h”
int recvfrom(int sockfd, void *buf, unsigned int len, int flags, struct sockaddr *src_addr, unsigned int *addrlen);
```

【Parameter】

int	sockfd	Socket FD
void *	buf	Address for receiving buffer
unsigned int	len	Length for receiving buffer
int	flags	Flag
struct sockaddr *	src_addr	Source address
unsigned int *	addrlen	Length of source address

【Return value】

int	Byte number which is received (included 0). On error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
	Cannot get the network buffer corresponding to “len”
EBADF	Socked FD cannot be received
ENOTCONN	Not be connected (TCP socket)
EAGAIN	The packet had not received yet. (During asynchronous execution)
ETIMEDOUT	Timeout (if the timeout is set)

【Explanation】

- The length for received buffer can be specified the value from 1 to 65535.
- The flag is not used, so any value is possible.
- If there are not any received packets, the recvfrom() function blocks the processes until reception of packet.
- If not yet connected to the remote as TCP socket, recvfrom () will result in an error.
- If in disconnected condition from remote with TCP socket, recvfrom () returns 0.
- For the TCP socket, Source address and Length of source address is not used.

5.5.4.12 shutdown (Close the part of the full-duplex connection)

【Format】

```
#include “sys/socket.h”
int shutdown(int sockfd, int how);
```

【Parameter】

int	sockfd	Socket FD
int	how	Direction for disconnection

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be shutdowned
EPIPE	Not be connected (TCP socket)

【Explanation】

- The Direction for disconnection can be specified only SHUT_WR or SHUT_RDWR.

5.5.4.13 close (Close the descriptor (socket))

【Format】

```
#include “sys/unistd.h”
int close(int fd);
```

【Parameter】

int	sockfd	Socket FD

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be closed.

【Explanation】

- If TCP socket had not disconnected yet, socket will close after disconnect TCP session.
- The closed socket FD cannot use until generate again.

5.5.4.14 select (Multiplexing of synchronous I/O)

【Format】

```
#include “sys/select.h”
int select(int nfds, fd_set *readfds, fd_set *writefds, fd_set *exceptfds, struct timeval *timeout);
```

【Parameter】

int	nfds	The value that maximum value in the socket FD included in the readfds and writefds, plus 1
fd_set *	readfds	Socket FD set to monitor whether readable
fd_set *	writefds	Socket FD set to monitor whether writable
fd_set *	exceptfds	Socket FD set to monitor the exception (not supported)
struct timeval *	timeout	Monitor timeout

【Return value】

int	The number of the socket FD which is writable or readable. On timeout, 0. On error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be selected.

【Explanation】

- The “exceptfds” is not used.
- Unlike the POSIX specification, in the execution of select() for the socket FD immediately after generation, it is writable for UDP socket (unreadable if not received the packet), or readable for TCP socket (unwritable).

5.5.4.15 getsockname (Get the name of the socket)

【Format】

```
#include “sys/socket.h”
int getsockname(int sockfd, struct sockaddr *addr, unsigned int *addrlen);
```

【Parameter】

int	sockfd	Socket FD
struct sockaddr *	addr	Buffer to store the socket address
unsigned int *	addrlen	Size of buffer to store the socket address

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be done getsokname.

【Explanation】

- For the *addrlen, user needs to set the size of the “sockaddr_in” (16 bytes or more).
- The socket address determined by the time that issued the following API.

  bind()

  connect()

  accept()

  send/sendto()

  recv/recvfrom()

  The socket address becomes the undefined value if these API failed.

5.5.4.16 getpeername (Get the name of the peer socket)

【Format】

```
#include “sys/socket.h”
int getpeername(int sockfd, struct sockaddr *addr, unsigned int *addrlen);
```

【Parameter】

int	sockfd	Socket FD
struct sockaddr *	addr	Buffer to store the remote address
unsigned int *	addrlen	Size of buffer to store the remote address

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be done getpeername.
ENOTCONN	The address is not set.

【Explanation】

- For the *addrlen, user needs to set the size of the “sockaddr_in” (16 bytes or more).
- In the case of TCP, user can get the remote address only for connected socket.
- In the case of UDP, user can get the remote address only for the socket which had set the address by “connect” or “sendto”, or the socket had already got a packet.

5.5.4.17 getsockopt (Get the socket options)

【Format】

```
#include “sys/socket.h”
int getsockopt(int sockfd, int level, int optname, void *optval, unsigned int *optlen);
```

【Parameter】

int	sockfd	Socket FD
int	level	Option level
int	optname	Option name
void *	optval	Buffer to store the value got
unsigned int *	optlen	Size of buffer to store the value got

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be done getsockopt.
EPROTONOSUPPORT	Unsupported option

【Explanation】

- The option level can be specified only SOL_SOCKET, IPPROTO_IP or IPPROTO_TCP.

The option name that user can get for each option level, please refer to 5.5.5Socket option.

5.5.4.18 setsockopt (Set the socket options)

【Format】

```
#include “sys/socket.h”
int setsockopt(int sockfd, int level, int optname, const void *optval, unsigned int optlen);
```

【Parameter】

int	sockfd	Socket FD
int	level	Option level
int	optname	Option name
const void *	optval	Buffer for the value to set
unsigned int	optlen	Size of buffer for the value to set

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EBADF	Socked FD cannot be done setsockopt.
EPROTONOSUPPORT	Unsupported option

【Explanation】

- The option level can be specified only SOL_SOCKET, IPPROTO_IP or IPPROTO_TCP.
- The option name that user can get for each option level, please refer to 5.5.5Socket option

5.5.4.19 ioctl (Control the device (socket))

【Format】

```
#include “sys/ioctl.h”
int ioctl(int d, int request, ...);
```

【Parameter】

int	d	Socket FD
int	request	Request
...		Request parameter

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

EINVAL	Parameter is incorrect
ENOMEM	Message buffer is depleted
EFAULT	Cannot expand the request parameters

【Explanation】

- The Request can be specified only FIONBIO (non-blocking connection setting).
- The request parameter for non-blocking communication setting is 1 (seting) or 0 (release).
- Regarding the non-blocking communication seeting, please refer to 5.5.6.1Non-blocking setting

5.5.4.20 inet_addr (Internet address manipulation routines)

【Format】

```
#include “arpa/inet.h”
unsigned int inet_addr(const char *cp);
```

【Parameter】

const char *	cp	The dot notation IP address

【Return value】

int	IP address binary value after conversion (network byte order)

【errno】

Not set

【Explanation】

- If the fail to convert happen, the return value is set to 0.

5.5.4.21 inet_aton (Internet address manipulation routines)

【Format】

```
#include “arpa/inet.h”
int inet_aton(const char *cp, struct in_addr *inp);
```

【Parameter】

const char *	cp	The dot notation IP address
struct in_addr *	inp	Buffer to store IP address binary value after conversion (network byte order)

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

Not set

【Explanation】

- If the fail to convert happen, the return value is set to -1.

5.5.4.22 inet_ntoa (Internet address manipulation routines)

【Format】

```
#include “arpa/inet.h”
char *inet_ntoa(struct in_addr in);
```

【Parameter】		
struct in_addr	in	IP address binary value (network byte order)

【Return value】	
Int	The dot notation IP address after conversion

【errno】

Not set

【Explanation】

- If the fail to convert happen, the return value is set to 0.
- If user call this function again after execution, the string will be overwritten, because the area stored the converted dot notation IP address is returned the string data stored the buffer which is assigned statically.

5.5.4.23 if_nametoindex (Mapping name and index of the network interface)

【Format】

```
#include “net/if.h”
unsigned int if_nametoindex(const char *ifname)
```

【Parameter】

const char *	ifname	Interface name

【Return value】

unsigned int	Interface index. On error, 0.

【errno】

ENXIO	Nonexistent interface name

【Explanation】

- The interface name is set by the device name (gNET_DEV[index-1].name [8]) to be used in the TCP/IP protocol stack.

5.5.4.24 if_indextoname (Mapping name and index of the network interface)

【Format】

```
#include “net/if.h”
char *if_indextoname(unsigned int ifindex, char *ifname)
```

【Parameter】

unsigned int	ifindex	Interface index
char *	ifname	Buffer for storing the interface name

【Return value】

int	Result of process. If success, ifname value, or on error, NULL.

【errno】

ENXIO	Nonexistent interface index

【Explanation】

- The interface name is set by the device name (gNET_DEV[index-1].name [8]) to be used in the TCP/IP protocol stack.

5.5.4.25 rresvport (Get the socket which is bound to port)

【Format】

#include “sys/unistd.h”

int rresvport(int *port)

【Parameter】

int *	port	Buffer to store port number

【Return value】

int	The socket FD which is bound to port. If socket is not existing, return -1.

【errno】

Not set

5.5.4.26 getifaddrs (Get the address of the interface)

【Format】

```
#include “sys/types.h”
int getifaddrs(struct ifaddrs **ifap)
```

【Parameter】

struct ifaddrs**	ifap	The start address of the interface information list

【Return value】

int	Result of process. If success, 0 or on error, -1.

【errno】

ENOMEM	Error as getting the stored area of intereface information

【Explanation】

- This function gets the interface information for the part of the number of devices (CFG_DEV_MAX) that are set in the application as chain.
- If successfully completed, the following values are stored in “ifap”.

  (*ifap)->ifa_next : The pointer of the next structure of interface information is stored. If the last element, this field is NULL.

  (*ifap)->name : The pointer to the interface name is stored.

  (*ifap)->ifa_flags : The device number is stored.

  (*ifap)->ifa_addr : The IP address of the device is stored as the sockaddr type pointer.

  (*ifap)->ifa_netmask : The subnet mask of the device is stored as the sockaddr type pointer.

  (*ifap)->ifa_ifu, (*ifap)->ifa_data : No use.
- After successful completion, user will need to release the interface information list in the freeifaddrs() function, because the interface information list is dynamically allocated.

5.5.4.27 freeifaddrs (Release the interface information)

【Format】

```
#include “sys/unistd.h”
void freeifaddrs(struct ifaddrs *ifa)
```

【Parameter】

struct ifaddrs*	ifap	The start address of the interface information list

【Return value】

void

【errno】

Not set

【Explanation】

- This function relase the interface information list which was got by getifaddrs() function.

5.5.5 Socket option

The following figure shows the list of option which can be set or got by setsockopt() or getsockopt()API. If anything other than the specified options, The function setsockopt() and getsockopt() will return -1.

Table 5.2 Socket option

Option name	Type	Function
SOL_SOCKET level		
SO_ACCEPTCONN	int	Get the LISTEN state of TCP socket. For Get only.
SO_BROADCAST	int	Affect only to UDP broadcast reception operation. For Get or Set.
SO_DOMAIN	int	Get the socket domain. For Get only.
SO_ERROR	int	Get the socket error. For Get only.
SO_KEEPALIVE	int	Enable the Keep-Alive function of TCP socket. For Set only.
SO_RCVBUF	int	Set the receive buffer. For TCP, it is a byte number of received window. For UDP, it is treated as a number of received packets (queue size). For Get or Set.
SO_RCVBUFFORCE	int	Same as for SO_RCVBUF.
SO_RCVTIMEO	timeval	Set the received timeout of socket. For Get or Set.
SO_SNDTIMEO	timeval	Set the sending timeout of socket. For Get or Set.
SO_TYPE	int	Get socket type. For Get only.
IPPROTO_IP level		
IP_ADD_MEMBERSHIP	ip_mreqn	Join the multicast group. For UDP socket only. For Set only.
IP_DROP_MEMBERSHIP	ip_mreqn	Drop from the multicast group. For Set only.
IP_MTU	int	Get path MTU. For Get only.
IP_MULTICAST_TTL	int	TTL setting for multicast sending packet. For Get or Set.
IP_TOS	int	TOS setting for IP sending packet. For Get or Set.
IP_TTL	int	TTL setting for IP sending packet. For Get or Set.
IPPROTO_TCP level		
TCP_KEEPCNT	int	Set the number of times of TCP Keep-Alive probe. For Set only.
TCP_KEEPIDLE	int	Set the non-communication interval of TCP Keep-Alive started. For Set only.
TCP_KEEPINTVL	int	Set the sending interval for TCP Keep-Alive probe. For Set only.
TCP_MAXSEG	int	Set the MSS value of TCP socket. For Get or Set.

5.5.6 Support function

5.5.6.1 Non-blocking setting

By using ioclt() function, user can set the call for socket API to non-blocking (or blocking). At the initial state, all of APIs are set as blocking. In the case of non-blocking setting, API may return -1, and set EAGAIN to error number. The following table shows API lists that non-blocking setting is available, the condition that error number becomes to EAGAIN, and the operation that application should behave.

The timeout setting by socket option doesn't affect to the API with non-blocking. And for the API of TCP/IP stack with BSD socket for R-IN32M3, the calling task may become the sleep state even under non-blocking setting, because of the spec through the inter-task communication.

Table 5.3 non-blocking API

API	Condition	Application behavior
connect	In the case of TCP socket, the return value is "-1", and error number is EAGAIN, always.	TCP socket continues to wait SYN/ACK from remote and resend SYN during the stipulated time, after returned -1. The TCP socket is monitored by writefds, because of becoming writable by select at the time of receiving the SYN / ACK. User does not need to run connect again after becoming writable.
accept	If there is no socket has been connected to the listen socket, the return value becomes "-1", and error number becomes EAGAIN.	The TCP socket is monitored by readfds, because of becoming readable by select at the time of receiving the SYN from remote. User should run accept again after becoming readable.
send sendto	In the case that it is TCP socket and the sending buffer is full, error number becomes EAGAIN. In the case that it is UDP socket and the socket is under sending, error number becomes EAGAIN.	EAGAIN means that the packet couldn't be sent by the condition of socket. (Then also packet is not sent.).
recv recvfrom	If packet has not received yet, error number becomes EAGAIN.	The socket is monitored by readfds, because of becoming readable by select at the time of receiving packet from remote. User should run recv again after becoming readable.

5.5.6.2 Loopback

If a local loopback address (127.0.0.1 ~ 127.255.255.254) is specified as the destination address, the packet is sent is notified to the network interface.

In the TCP/IP stack with BSD for R-IN32M3, loopback address does not have a specific device interface, it is treated as a send-only address. So, it is not possible to run the bind() function for loopback address.

5.5.6.3 Error handling

Symbol errno is the only global variables. This value is updated in accordance with the error that occurred during the API execution. If user wants to run the API from multiple tasks, it is recommended that user gets the last of errno that occurred within a task with using get_errno() function, in order to guarantee the integrity of errno.

【Format】

```
#include “sys/errno.h”
int get_errno(void)
```

【Parameter】

void

【Return value】

int	The last of errno that occurred within a task called from this API.

【errno】

Not set

【Explanation】

- errno of each task is stored in the global variable UW tsk_errno[] which is the application prepared. User needs to pre-set the maximum number of tasks in this array element.

Table 5.4 errorno list

errno	Value	Explanation
ENXIO	6	Interface is not existed.
EBADF	9	Socket FD is invalid.
ENOMEM	12	Out of memory
EFAULT	14	Parameter error
ENODEV	19	A fatal abnormality(or unknown) in the system
EINVAL	22	Parameter error
EPIPE	32	Socket object is invalid
EAGAIN	35	Run the blocking processing
EALREADY	37	Processing of already running
EDESTADDRREQ	39	Need a destination set
EPROTONOSUPPORT	43	Function is not supported
EAFNOSUPPORT	47	Address family is not supported
EADDRINUSE	48	Address is already in use
EADDRNOTAVAIL	49	Address is not available
EISCONN	56	Socket is already connected
ENOTCONN	57	Socket is not connected
ETIMEDOUT	60	Time out
ECONNREFUSED	61	Connection is denied

5.5.7 Implementation of BSD application

5.5.7.1 Source code

Application which uses the BSD sockets needs to bind 4 files (unet3_iodev.c, unet3_option.c, unet3_socket.c, unet3_wrap.c) in the folder “Middleware/uNet3/bsd/” to the application project.

```
Middleware
  |
  +--uNet3
      +--bsd
         +--unet3_lodev.c
         +--unet3_option.c
         +--unet3_socket.c
         +--unet3_wrap.c
```

In addition, user will need to link library for BSD called “libunet3bsd.a”.

```
Library
 |
 └────ARM or GCC or IAR
         +--libune3bsd.a       /* Library for BSD socket */
```

5.5.7.2 Include path

Application which uses the BSD sockets needs to add the directry “unet3_posix” and “inc” in the folder “Middleware/uNet3/bsd/” as a include path in the setting.

```
Middleware
  |
  +--uNet3
      +--bsd
         |
         +--unet3_posix   /* Include base folder for BSD socket */
         |   |   :
         |
         +--inc           /* Include base folder of uNet3 socket */
```

5.5.7.3 Configuration

In the TCP/IP stack with BSD for R-IN32M3, the maximum number of sockets and the number of the task of application is needed to macro defined in unet3_cfg.h, in advance.

The maximum number of sockets

```
#define     BSD_SOCKET_MAX
```

The maximum number of sockets, regardless of the protocol, shows the number of sockets that application generates at the same time (including also listen backlog). This macro definition is used for definition of the management table number of BSD socket and fd_set type, which will be described later. This value must be the same value as the µNet3 socket maximum number (CFG_NET_SOC_MAX).

Number of application tasks

```
#define     NUM_OF_TASK_ERRNO
```

The number of application tasks is the task number that can be generated in the kernel. This macro definition is used to the management table number of error number, which will be described later. This value, regardless of the use or non-use of BSD, should be set the number of generatable task.

5.5.7.4 Resource definition

Application which uses the BSD sockets needs to prepare a table for managing information.

BSD socket management table

```
T_UNET3_BSD_SOC    gNET_BSD_SOC[BSD_SOCKET_MAX];
```

BSD socket management table defines a global variable as T_UNET3_BSD_SOC-type array that the number of elements is BSD_SOCKET_MAX.

Error number management table

```
UW tsk_errno[NUM_OF_TASK_ERRNO];
```

Error number management table defines a global variable as T_UNET3_BSD_SOC-type array that the number of elements is NUM_OF_TASK_ERRNO.

5.5.7.5 Kernel objects

Kernel objects that TCP/IP stack with BSD for R-IN32M3 uses, is as follows.

Resource name	Use	ID
Task	BSD Wrapper task	ID TSK_BSD_API
	Loopback device task	ID_LO_IF_TSK
Mailbox	Communication between the BSD Wrapper task	ID MBX_BSD_REQ
	Communication between the loopback device task	ID_LO_IF_MBX

5.5.7.6 Initialization

Application needs to initialize the BSD module by calling the unet3_bsd_init() function, before using the BSD sockets API. In addition, before this BSD module initialization, the initialization of the uNet3 and device driver are needed to be completed successfully.

【Format】

```
#include “sys/socket.h”
ER unet3_bsd_init(void)
```

【Parameter】

void	

【Return value】

ER	Result of process. If success, E_OK. or if error, error code.

【errno】

E_SYS	Failed to initialize the process of kernel objects

Example of use

```
ER net_sample(void)
{
    /* Initialize TCP/IP Stack */
    ER ercd;

    ercd = net_ini();
    if (ercd != E_OK) {
        return ercd;
    }

    /* Initialize Ethernet Driver */
    ercd = net_dev_ini(1);
    if (ercd != E_OK) {
        return ercd;
    }

    /* BSD wrapper */
    ercd = unet3_bsd_init();

    return ercd;
}
```

5.6 Other API

htons	Convert 16 bit value to network byte order

【Format】

UH htons(UH val);

【Parameter】

UH	val	16 bit value host byte order

【Return value】

UH	16 bit value to network byte order

htonl	Convert 32 bit value to network byte order

【Format】

UW htonl(UW val);

【Parameter】

UW	val	32 bit value host byte order

【Return value】

UW	32 bit value network byte order

ntohs	Convert 16 bit value to host byte order

【Format】

UH ntohs(UH val);

【Parameter】

UH	val	16-bit value network byte order

【Return value】

UH	16-bit value host byte order

ntohl	Convert 32 bit value to host byte order

【Format】

UW ntohl(UW val);

【Parameter】

UW	val	32 bit value network byte order

【Return value】

UW	32 bit value host byte order

ip_aton	Convert an IPv4 address string in dot-notation to 32 bit value

【Format】

UW ip_aton(const char *str);

【Parameter】		
char	str	Pointer to IPv4 address string in dot-notation
【Return value】		
UW	>0	Successful completion (32 bit value after converting)
【Error code】		
0	Wrong IP address is specified	

ip_ntoa	Convert 32-bit value IPv4 address to IPv4 address string in dot-notation

【Format】

void ip_ntoa(const char *str, UW ipaddr);

【Parameter】		
char	str	Pointer that accepted IP address string after converting
UW	ipaddr	32-bit value IP address
【Return value】		
None		

【Explanation】

If the process completes successfully, the character string will be set in str, but str will be NULL if the error occurs.

ip_byte2n	Convert IPv4 address array to 32 bit value

【Format】

UW ip_byte2n(char *ip_array);

【Parameter】

char	ip_array	Pointer to byte value array of IP address

【Return value】

UW	>0	Successful completion (32-bit value after converting)

【Error code】

0	Wrong IP address is specified

ip_n2byte	Convert 32 bit value IPv4 address to array

【Format】

void ip_n2byte(char *ip_arry, UW ip);

【Parameter】

char	ip_array	Pointer to byte value array of IP address
UW	ip	32-bit value IP address

【Return value】

None

【Explanation】

After completing successfullyl, value is set in asip_array. In case of error, ip_array turns into NULL.

6. Network application

6.1 DHCP client

DHCP client obtains IP address information which is used in network from DHCP server. Acquired IP address is assigned to the host.

SE THIS FUNCTION OF RENEW, RELEASE, DECLINE, FEATURES INFORM. FOR DHCP EXTENDED VERSION, SEE THE EXTENDED VERSION 6.5 DHCP CLIENT.

(1) Host address information

```
typedef struct t_host_addr {
        UW      ipaddr;         /* IP address */
        UW      subnet;         /* Subnet Mask */
        UW      gateway;        /* Gateway*/
        UW      dhcp;           /* DHCP Server address */
        UW      dns[2];         /* DNS Address */
        UW      lease;          /* Lease period of the DHCP address*/
        UW      t1;             /* Renewal period of DHCP address*/
        UW      t2;             /* Rebind period of DHCP address */
        UB      mac[6];         /* MAC address */
        UB      dev_num;        /* Device address */
        UB      state;          /* DHCP Cliente status*/
        UH      socid;          /* ID of UDP socket*/
} T_HOST_ADDR ;
```

This structure is used as an argument of DHCP client API. **Device number** and **ID of UDP socket** have to be set by user application. The remaining parameters are set by the response from a DHCP server.

- ID of UDP socket

In DHCP client, use UDP socket. UDP socket must be created by the following parameter. (It is created in DHCP client applications)

Protocol	ID	Port	Transmission timeout	Reception timeout
UDP	ID_SOC_DHCP	68	3 seconds	3 seconds

- Device number

In device number, specify network device used by DHCP client. If specify '0 ', default network device is used

6.1.1 DHCP client API

dhcp_client	Starting DHCP Client	
【Format】		
ER ercd = dhcp_client(T_HOST_ADDR *addr);		
【Parameter】		
T_HOST_ADDR	*addr	host address information
【Return value】		
ER	ercd	Successful completion (E_OK) or error code
【Error code】		
E_PAR	*addr is NULL or socid is specified	
E_OBJ	Socket status is wrong (socket has not been created yet)	
E_TMOUT	Response from DHCP server delays. Or DHCP server does not exist	

【Explanation】

This API acquires an IP address, a subnet mask, a gateway address from a DHCP server and assigns them to host. Maybe E_TMOUT error occurs due to the construction of using network. At that time, we recommend that you try to retry until it succeeds.

This API will also initiate a new DHCP session. When you call the API, you will start to send operation DISCOVER always expect receive OFFER, send REQUEST, the reception of the ACK that is.

The expiration of an IP address which is acquired from a DHCP server is specified 'lease (lease period).
As follows: DHCP client to do lease before the lease period expires.

DHCP client example (Exclusive task)

```
void dhcp_tsk(VP_INT exinf)
{
    ER ercd;
    T_HOST_ADDR dhcp_addr = {0};
    UB status = DHCP_STS_INIT;

    dhcp_addr.socid = ID_SOC_DHCP;
    dhcp_addr.dev_num = ID_DEVNUM_ETHER;

    for (;;) {
        ercd = dhcp_client(&dhcp_addr);
        if (ercd == E_OK) {
            /* BOUND period */
            dly_tsk(dhcp_addr.t1*1000);
            /* RENEWING period */
            status = DHCP_STS_RENEWING;
            continue;
        }
        if (status == DHCP_STS_RENEWING) {
            /* REBINDING period */
            dly_tsk((dhcp_addr.t2-dhcp_addr.t1)*1000);
            status = DHCP_STS_INIT;
            continue;
        }
        /* INIT period */
        dly_tsk(1000);
    }
}
```

If it is need to update the lease on the DHCPREQUEST message, please use the extended version of DHCP CLient.

6.2 FTP Server

FTP server enables to download and upload files to the remote host.

FTP Server Control Information

```
typedef struct t_ftp_server {
        UB      dev_num;        /* Device Number*/
        UH      ctl_socid;      /* ID Socket used for Command */
        UH      data_socid;     /* ID Socket used for data*/
        UB      *fs_file;       /* Store buffer */
        UW      fs_maxsz;       /* Store buffer size */
} T_FTP_SERVER ;
```

Set necessary information in this structure and then transfer as argument of FTP Server API.

- Device Number

In device number, specify network device used in FTP server. In case of specifying “0”, default network device will be used (Please set 0 normally)

- TCP socket

FTP server requires two TCP sockets for commands and data. TCP socket should be created in the following parameters. (It will be created in the FTP server application)

Socket used for command:

ID	Protocol	Port	Timeout				Buffer size	
			send	receive	connect	interrupt	send	receive
ID_SOC_FTP_CTL	TCP	21	5s	15s	-1s	5s	1024	1024

Socket used for data:

ID	Protocol	Port	Timeout				Buffer size	
			send	receive	connect	interrupt	send	receive
ID_SOC_FTP_DATA	TCP	20	5s	15s	5s	5s	1024	1024

- FTP file saving

In this FTP server, because it does not support file system, received files are stored in memory. Please set memory address of storing location in store buffer. In addition, please set size of memory of storing location in Store buffer size.

6.2.1 FTP Server API

ftp_server	Start up FTP Server	
【Format】		
ER ercd = ftp_server(T_FTP_SERVER *ftp);		
【Parameter】		
T_FTP_SERVER	*ftp	FTP server control information
【Return value】		
ER	ercd	Successful completion (E_OK) or error code
【Error code】		
E_PAR	Wrong parameter is specified (*fpt is NULL. ctl_socid or data_socid is not specified *fs_file is NULL fs_maxsz is zero)	

【Explanation】

This API initializes FTP server, accepts and processes requests from FTP clients. Because this API becomes blocking calling, please use specific task to call it.

FTP server example

```
T_FTP_SERVER ftpd;
UB ftp_buf[1024];

/* FTP server task */
void FtpServerTask(VP_INT exinf)
{
   memset((char*)&ftpd, 0, sizeof(ftpd));
   ftpd.ctl_socid = ID_SOC_FTP_CTL;
   ftpd.data_socid = ID_SOC_FTP_DATA;
   ftpd.fs_file = ftp_buf;
   ftpd.fs_maxsz = 1024;
   ftp_server(&ftpd);
   ext_tsk();
}
```

6.2.2 Restriction terms

- Supported command includes login, put, get, quit.
- Do not support file system. Therefore, impossible to create directory structure and handle multiple files.

6.3 HTTP server

HTTP server transmits content to HTTP client (internet browser) statically and dynamically.

(1) HTTP content information

```
typedef struct t_http_file {
    const char      *path;                      /* URL */
    const char      *ctype;                     /* Content type */
    const char      *file;                      /* Content */
    Int             len;                        /* Content size*/
                                                /* HTTP callback function
    void(*cbk)(T_HTTP_SERVER *http);            or
                                                CGI handler */
} T_HTTP_FILE ;
```

Register content to be used in HTTP server in this structure.

- URL

Show URL of content. For example, if there is request from client to that URL, corresponding content will be sent to client.

Impossible to specify NULL in URL. Besides, URL starts by `/ as usual.

- Content type

Specify Content-Type of text/html etc. In case of dynamic content, specify NULL.

- Content

Specify actual content. In case of dynamic content, specify NULL.

- Content size

Specify size of content. In case of dynamic content, specify 0.

- Callback function or CGI handler

When it's dynamic content, specify pointer of the function called from HTTP server. In case of static content, specify NULL.

(2) HTTP server control information

```
typedef struct t_http_server {
    UB              NetChannel;     /* Device number*/
    UH              Port;           /* Listening port number*/
    UH              SocketID;       /*   ID socket */
    UW              sbufsz;         /* transmission buffer size */
    UW              rbufsz;         /* reception buffer size*/
    UB              *rbuf;          /* transmission buffer*/
    UB              *sbuf;          /* reception buffer*/
    UB              *req;           /* internal data*/
    UW              txlen;          /*internal data */
    UW              rxlen;          /* internal data*/
    UW              rdlen;          /* internal data*/
    UW              len;            /* internal data*/
T_HTTP_HEADER       hdr;            /* HTTP client request */
} T_HTTP_SERVER;
```

This structure is used as argument of HTTP server API. ID socket needs to be set by user application.

- Device number

For device number, specify network device to use in HTTP server. In case of specifying “0”, default network device is used. (Please set “0” normally).

- ID socket

In HTTP server, use TCP socket. TCP socket needs to be created by the following parameter. (It will be created in HTTP server application).

ID	protocol	port	timeout				Buffer size	
			send	receive	connect	interrupt	send	receive
ID_SOC_HTTP	TCP	80	25s	25s	25s	25s	1024	1024

- Transmit buffer Receive buffer

In the HTTP server uses the network protocol stack buffers for each send and receive packets.

And receive buffers (transmit), if you (for example, you want to send content to a larger network buffers, for example) for reasons such as content size, you want to use your own buffer application in which the value of the buffer own buffer size (send) and receive set. You will not get the network buffer on the HTTP server in that case.

Own area set cannot be shared with other processes HTTP server also.

6.3.1 HTTP server API

http_server	Start up HTTP server

【Format】

ER ercd = http_server(T_HTTP_SERVER *http);

【Parameter】

T_FTP_SERVER	*http	HTTP server control information

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_PAR	Wrong parameter is specified (*http is NULL. SocketID is not specified.)

【Explanation】

This API initializes HTTP session, then accepts and processes request from HTTP client. In case the URL which is requested from client exists in content table (T_HTTP_FILE), send that content to client, if not, send HTTP error message”404 File not found”. In case content is dynamic (cbk is not NULL), call that callback function.

Because this API becomes blocking call, please use a specific task to call it.

If NULL, the receive buffer of the control information of the argument is HTTP server uses the network buffer.

If NULL, the transmit buffer of the control information of the argument is HTTP server uses the network buffer.

CgiGetParam	CGI argument analysis

【Format】

void CgiGetParam(char *msg, int clen, char *cgi_var[], char *cgi_val[], int *cgi_cnt);

【Parameter】

char	*msg	CGI argument
int	clen	CGI argument size
char	*cgi_var[]	Analysed CGI argument
char	*cgi_val[]	Value of analysed CGI argument
int	*cgi_cnt	Number of articles of the analysed CGI argument

【Return value】

None

【Error code】

None

【Explanation】

This API analyses query string to be constructed in “field value” group. For example, analysis result in case of query string is given as “name1=value1&name2=value2” as below.

cgi_cnt = 2;

cgi_var[0] = “name1”;
cgi_var[1] = “name2”;

cgi_val[0] = “value1”;
cgi_val[1] = “value2”;

HttpSendText	Transmission of text content

【Format】

ER ercd = HttpSendText(T_HTTP_SERVER *http, char *str, int len);

【Parameter】

char	*http	HTTP server control information
int	*str	String to transmit
int	len	length of string to transmit

【Return value】

ER	ercd	Successful completion only (E_OK)

【Error code】

None

【Explanation】

This API transmits dynamic content. Please call this API only from HTTP callback function.

Example

```
char page1[] = “<html><body>Welcome to this web server </body></html>”;

void Http_Callback(T_HTTP_SERVER *http)
{
   HttpSendText(http, page1, sizeof(page1));
}
```

HttpSendFile	Send Attached File

【API】

ER HttpSendFile(T_HTTP_SERVER*http, char*str, int len, char*name, char *type);

【Parameter】

T_HTTP_SERVER	*http	HTTP server information
char	*str	File to be send
int	len	Length to be send
char	*name	Filename
char	*type	Content-Type value or strings of HTTP header

【Return Value】

ER	ercd	Success (E_OK)

【Error Code】

None

【DESCRIPTION】

This API sends the dynamic content. Please only be called from this API function callback HTTP.

Send file attachments in API: This is sent in (Content-Disposition attachment).

Use Case

```
char file[1024];

void Http_Callback(T_HTTP_SERVER *http)
{
int len;
                    :
/* Specify the “file” of contents, the size set to “len” */
                    :
   HttpSendFile(http, file , len, “FILE NAME”, “text/plain”);
}
```

HttpSendImage	Send Image Content

【API】

ER ercd = HttpSendImage(T_HTTP_SERVER *http, char *str, int len);

【Parameter】

T_HTTP_SERVER	*http	HTTP server information
char	*str	Image data to be send
int	len	Length to be send

【Return Value】

ER	ercd	Success (E_OK)

【Error Code】

None

【DESCRIPTION】

This API sends the dynamic content. Please only be called from this API function callback HTTP.

6.3.2 HTTP server sample

```
/* Definition of content */
const char index_html[] =
"<html>\
<title> uNet3 HTTP Server </title>\
<body>\
<h1>Hello World!</h1>\
</body>\
</html>";

/* Initialization of content list */
T_HTTP_FILE const content_list[] =
{
      {"/", "text/html", index_html, sizeof(index_html), NULL},
      {"", NULL, NULL, 0, NULL} /* terminal */
};

/* Starting HTTP session */
static T_HTTP_SERVER http_server1;
void httpd_tsk1(VP_INT exinf)
{
/* Initialize the content list global pointer */
gHTTP_FILE = (T_HTTP_FILE*)content_list;

memset((char* )&http_server1, 0, sizeof(http_server1));
      http_server1.SocketID = ID_SOC_HTTP1;

      http_server(&http_server1);
}
```

6.4 DNS client

In DNS client, use UDP socket. UDP socket will be created by the below parameter.

ID	protocol	port	timeout	
			send	receive
ID_SOC_DNS	UDP	0	5s	5s

6.4.1 DNS client API

dns_get_ipaddr	Acquire IP address from host name

【Format】

ER ercd = dns_get_ipaddr(ID socid, UW dns_server, char *name, UW *ipaddr);

【Parameter】

ID	socid	UDP socket ID
UW	dns_server	IP address of DNS server
char	*name	Host name
UW	*ipaddr	IP address to acquire

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_PAR	Wrong parameter is specified
E_TMOUT	No response from DNS server
E_NOMEM	Memory error
E_OBJ	Unable to resolve IP address from host name

Example of use

```
UW ip;
ER ercd;
UW dns_server = ip_aton(“192.168.11.1”);

dns_get_ipaddr(ID_SOC_DNS, dns_server, “www.eforce.co.jp”, &ip);
```

dns_get_name	Acquire host name from IP address

【Format】

ER ercd = dns_get_name(ID socid, UW dns_server, char *name, UW *ipaddr);

【Parameter】

ID	socid	UDP socket ID
UW	dns_server	IP address of DNS
char	*name	host name to acquire
UW	*ipaddr	IP address

【Return value】

ER	ercd	Successful completion (E_OK) or error code

【Error code】

E_PAR	Wrong parameter is specified
E_TMOUT	No response from DNS server
E_NOMEM	Memory error
E_OBJ	Unable to acquire host name from IP address

Example of use

```
UW ip = ip_aton(“192.168.11.30”);
ER ercd;
char host_name[256];
UW dns_server = ip_aton(“192.168.11.1”);

dns_get_name(ID_SOC_DNS, dns_server, host_name, &ip);
```

6.5 DHCP Client

For the existing DHCP client, holds the lease on the resources of the state, such as IP, DHCP client extended version information (RENEW), release (RELEASE), denial (DECLINE), a restart (REBOOT), an extension of these has been enhanced to provide the function get (INFORM).

(1) DHCP Client Information

```
typedef struct t_dhcp_client {
        T_DHCP_CTL      ctl             /* Control Informatio */
        UW              ipaddr;         /* IPaddress*/
        UW              subnet;         /* Subnet Mask */
        UW              gateway;        /* Gateway Address */
        UW              dhcp;           /* DHCPserver address */
        UW              dns[2];         /* DNSAddress */
        UW              lease;          /* Release time for DHCP Addless */
        UW              t1;             /* Renewal DHCP address */
        UW              t2;             /* Rebind time of DHCP address.*/
        UB              mac[6];         /* MAC addresss */
        UB              dev_num;        /* Device number */
        UB              state           /* Status of DHCP Clients */
        UH              socid;          /* UDP with socket ID */
        UB              arpchk;         /* Duplicate IP check */
} T_DHCP_CLIENT ;
```

This structure is intended to be used as an argument to the DHCP client API, is an extension of the host address information structure. The same manner as described above, UDP socket ID number and device must be set by the user application. Please refer to the DHCP client is the value to be set.

If you set the "ARP_CHECK_ON" to check whether or not duplicate IP, you do the duplicate check using the ACD feature for the IP, which is leased from the DHCP server.

This structure is used, even when I update the IP address that you set IP address at the time of acquisition. We cannot change the DHCP client state and control information in the application for that.

6.5.1 DHCP Client Extended API

dhcp_bind	Get DHCP Lease Information

【API】

ER ercd = dhcp_bind(T_DHCP_CLIENT *dhcp);

【Parameter】

T_DHCP_CLIENT	*dhcp	DHCP Client Information

【Return Value】

ER	ercd	Success (E_OK) or Error Code

【Error Code】

E_PAR	DHCP is NULL
E_OBJ	Incorrect Socket status (No create the socket)
E_SYS	Address conflict another host when the IP address is assigned.
E_TMOUT	Response is delay from DHCP server or the DHCP server doesn't exist.

【DESCRIPTION】

This API provides the same functionality as the () API dhcp_client traditional.

To verify the IP address that you get that you do not have overlap with other hosts, we set up a check for duplicate IP ARP_CHECK_ON the presence of DHCP client information of the argument. If a duplicate IP address is detected at this time, to send a message to the DHCP server DHCP_DECLINE, API will return the E_SYS.

dhcp_renew	Renewal DHCP Lease

【API】

ER ercd = dhcp_renew(T_DHCP_CLIENT *dhcp);

【Parameter】

T_DHCP_CLIENT	*dhcp	DHCP Client Information

【Return Value】

ER	ercd	Success(E_OK) or Error Code

【Error Code】

E_PAR	DHCP is NULL
E_OBJ	Incorrect DHCP client, or request denied by DHCP server.
E_SYS	Address conflict another host when the IP address is assigned.
E_TMOUT	Response is delay from DHCP server or the DHCP server doesn't exist.

【DESCRIPTION】

This API to extend the validity period of IP address obtained from the DHCP server. The argument specifies the DHCP client information obtained by dhcp_bind ().

This API should be called (t_1) within the validity period. Lifetime is measured by the application using the timer or control task.

This feature also includes the ability RENEW REBIND. The difference between the two is only to send broadcast messages to send unicast REQUEST. If you cannot receive the ACK after sending a REQUEST message to the DHCP server at the beginning, we perform a broadcast transmission immediately.

To verify the IP address that the extension does not have an overlap with other hosts, we set up a check for duplicate IP ARP_CHECK_ON the presence of DHCP client information of the argument. If a duplicate IP address is detected at this time, to send a message to the DHCP server DHCP_DECLINE, API will return the E_SYS.

dhcp_reboot	DHCP Client Reboot

【API】

ER ercd = dhcp_reboot(T_DHCP_CLIENT *dhcp);

【Parameter】		
T_DHCP_CLIENT	*dhcp	DHCP Client Information

【Return Value】		
ER	ercd	Success(E_OK) or, Error Code

【Error Code】	
E_PAR	DHCP is NULL or there is no address available.
E_OBJ	Illegal DHCP client information or DHCP server has refused the request.
E_SYS	The assigned IP address conflict with another host.
E_TMOUT	Delayed response from the DHCP server. Or DHCP server does not exist.

【DESCRIPTION】

This API is reusing the IP resource to which the client was previously used, API is used to verify its legitimacy in DHCP server. If you do not, such as when you remove and insert the LAN cable or if the LAN interfaces in the pause is activated again, and security that are part of the same network before and after, the DHCP server for the IP resource that has been previously used, for example notice.

The argument specifies the DHCP CLIENT INFORMATION dhcp_bind acquired by ().

If an ACK is not received after sending REQUEST message, API This is an error, or if it receives a DHCPNAK.

To verify the IP address that you notice that you do not have overlap with other hosts, we set the duplicate IP ARP_CHECK_ON to check whether or not the argument of the DHCP CLIENT INFORMATION. If a duplicate IP address is detected at this time, to send a message to the DHCP server DHCP_DECLINE, API will return the E_SYS.

dhcp_release	Release DHCP Lease Information

【API】

ER ercd = dhcp_release(T_DHCP_CLIENT *dhcp);

【Parameter】		
T_DHCP_CLIENT	*dhcp	DHCP CLIENT INFORMATION
【Return Value】		
ER	ercd	Success (E_OK) or Error Code
【Error Code】		
E_PAR	DHCP is NULL	
E_OBJ	Illegal DHCP client information	
E_TMOUT	Timeout send DHCPRELEASE message	

【DESCRIPTION】

This API will notify the DHCP server to release the resources when it no longer want to use the IP address obtained from the DHCP server.

The argument specifies the DHCP information obtained dhcp_bind in ().

dhcp_inform	Get DHCP Options

【API】

ER ercd = dhcp_inform(T_DHCP_CLIENT *dhcp);

【Parameter】		
T_DHCP_CLIENT	*dhcp	DHCP CLIENT INFORMATION
【Return Value】		
ER	ercd	Success (E_OK) or Error Code
【Error Code】		
E_PAR	DHCP is NULL.	
	Or, there isn't available of the address.	
E_OBJ	No specified the IP address b Host.	
E_TMOUT	Delay DHCP server response. Or no existence DHCP server.	

【DESCRIPTION】

This API to get the information other than the IP address from the DHCP server. Set the static IP address, for example, the address of the DNS server is used, for example, if you want to get from the DHCP server.

To the argument set DHCP CLIENT INFORMATION (for R-IN32M3 TCP/IP stack) only socket ID and device number of the interface.

6.5.2 DHCP Client information Extended

DHCP Client Extended Information

```
void dhcp_client_tsk(VP_INT exinf)
{
	ER ercd;
	FLGPTN ptn;
	T_DHCP_CLIENT dhcp_client = {0};

	dhcp_client.dev_num = ID_DEVNUM_ETHER;
	dhcp_client.socid = ID_SOC_DHCP;

	while (1) {
		ercd = dhcp_bind(&dhcp_client);

		while (ercd == E_OK) {
			/* Set Time event setup t1 */

			wai_flg(ID_DHCP_FLG, 0xFFFF, TWF_ORW, &ptn);

			/* t1 timeout */
			if (ptn & T1_EVENT) {
				ercd = dhcp_renew(&dhcp_client);
			}
			/* re-boot */
			else if (ptn & REBOOT_EVENT) {
				ercd = dhcp_reboot(&dhcp_client);
			}
		}
		dly_tsk(1000);
	}
	dhcp_release(&dhcp_client);
}
```

6.6 Ping Client

For any destination, Ping client sends the ICMP echo request. We found that in the IP address of the communication is possible if there is an echo response from the other party.

In addition, Ping client sends and receives using the ICMP socket. If R-IN32M3 TCP/IP stack use the socket ID "ID_ICMP" that is reserved by check instead of defining the ICMP socket, to "use the request ICMP Echo" from the net Configurator application.

6.6.1 Ping Client API

ping_client	ICMP Echo (Transmite Request and Receive Response)

【API】

ER ping_client(T_PING_CLIENT *ping_client);

【Parameter】		
T_PING_CLIENT	*ping_client	Ping transmit information

【Return Value】		
ER	ercd	Success (E_OK) or Error Code

【Error Code】	
E_PAR	Specified the incorrect Parameter
E_TMOUT	No response from remote or failed address resolver
E_NOMEM	Memory Error
E_OBJ	Incorrect ping transmit information

【DESCRIPTION】

This API sends a ping to the IP address that you set in the argument. I continue to wait for a response from the other party and then I get a timeout that is specified in the argument to expire. If you get a response I will return E_OK.

This API is limited to IPv4.

Use Case

```
ER ping_send(void)
{
	T_PING_CLIENT ping = {0};
	ER ercd;

	ping.sid = ID_ICMP;
	ping.devnum = ID_DEVNUM_ETHER;
	ping.tmo = 1000; /* Timeout 1 second*/
	ercd = ping_client(&ping);
	if (ercd == E_OK) {
		/* ping success */
	}
	return ercd;
}
```

6.7 SNTP Client

SNTP client get the (number of seconds starting from 1/1/1900) time from NTP (NTP) server time on the network using the NTP packet.

6.7.1 SNTP Client API

sntp_client	Get NTP time	

【API】

ER sntp_client(T_SNTP_CLIENT *sntp_client, UW *sec, UW *msec);

【Parameter】

T_SNTP_CLIENT	*sntp_client	Information of SNTP client
UW	*sec	MTP Time (second)
UW	*msec	NTP Time(32-bit fixed-point representation below the decimal)

【Return Value】

ER	ercd	Success (E_OK) or Error Code

【Error Code】

E_PAR	Specified the illegal parameter
E_TMOUT	No response from remote or failed address resplver
E_NOMEM	Memory Error
E_OBJ	Incorrect Information of SNTP client

【DESCRIPTION】

This API gets the time from NTP NTP server you set up in the argument. To set the NTP server, specify the IPv4 address and port number.

In the SNTP client uses the UDP socket. If R-IN32M3 TCP/IP stack argument should be set to the socket ID available.

This API returns the E_OK if you can successfully get the time NTP.

NTP time is shown in the sec and msec arguments at this time. Because you are starting from 1/1/1900, NTP time and the conversion to Unix time (JST) UTC must be calculated by the caller.

Use Case

```
ER sntp_time(void)
{
	T_SNTP_CLIENT sntp = {0};
	UW sec, msec;
	ER ercd;

	sntp.sid = ID_UDP;
	sntp.devnum = ID_DEVNUM_ETHER;

	ercd = sntp_client(&sntp, &sec, &msec);
	if (ercd == E_OK) {

		/* Convert to Unix Time */
		sec -= 2208988800;

		/* Accuracy for ms */
		msec >>= 16;
		msec *= 1000;
		msec >>= 16;
	}
	return ercd;
}
```

6.8 String Library

R-IN32M3 TCP/IP stack system provides a standard library of String so that it is not dependent on the compiler. Network applications you can use to provide these functions.

net_strncasecmp	Compare String (case-insensitive letter)

【API】

W net_strncasecmp(const char *str1, const char *str2, W len);

【Parameter】

const char *	str1	String to be compared
const char *	str2	String to be compared
W	len	Length of compare

【Return Value】

W	Result

【DESCRIPTION】

The results were compared with the character code, it will return 0 if str1 = str2. The return value is positive if str1> str2, and is negative if str1 <str2.

I arrived at the end of either string number of characters until it reaches the comparison is to be compared. By this function equate the case of the letters.

net_strcmp	String Compare

【API】

W net_strcmp(const char *str1, const char *str2);

【Parameter】

const char *	str1	String to be compared
const char *	str2	String to be compared

【Return Value】

W	Result of Compare

【DESCRIPTION】

The results were compared with the character code, it will return 0 if str1 = str2. The return value is positive if str1> str2, and is negative if str1 <str2.

Reach the end of the string until one of them to be compared

net_strcpy	String Copy

【API】

char* net_strcpy(char *str1, const char *str2);

【Parameter】

char *	str1	Address of copy destination string
const char *	str2	Address of copy source string

【Return Value】

char*	str1	Address of copy destination string

【DESCRIPTION】

This API is to copy of the srt2 to the end of str1 (NULL).

net_strlen	Get String Length

【API】

UW net_strlen(const char *str);

【Parameter】

char *	str	String

【Return Value】

UW		String length

【DESCRIPTION】

Gets the number of characters up to (NULL) end of str. (NULL is not included)

net_strcat	String concatenation

【API】

char* net_strcat(char *str1, const char *str2);

【Parameter】

char *	str1	Address of destination string
const char *	str2	Address of source string

【Return Value】

char	str1	Address of destination string

【DESCRIPTION】

Copy to the end of the str2 starting at (NULL) coupling the end of the destination string str1.

net_strchr	Search Character	

【API】

char* net_strchr(const char *str, int ch);

【Parameter】

const char *	str	Search target character
Int	ch	Search character

【Return Value】

char	str	In the subject string, address search string appears. If the search string does not appear NULL

7. Tutorial by sample application

In this chapter, the way to run the TCP/IP stack sample application is showed, and the behavior of it is confirmed.

7.1 Descriptions of sample software

"uNet3_sample" under the directory "Project" is used. This sample software lets us confirm HTTP server.

- Web server
  LED flashing period can be changed by 100 msec unit from the Web browser.

Please refer to *2.3 Directory and file organization* for a list of files included in sample software. And please note that R-IN32M3 TCP/IP stack is need to merge to driver and middleware sample program.

7.2 Hardware connection

Please check file DDR_ETH_CFG.h.
If macro USE_ETHSW is set to 0, please use the R-IN32-EC board's RJ45 **PORT1**. See following figure.

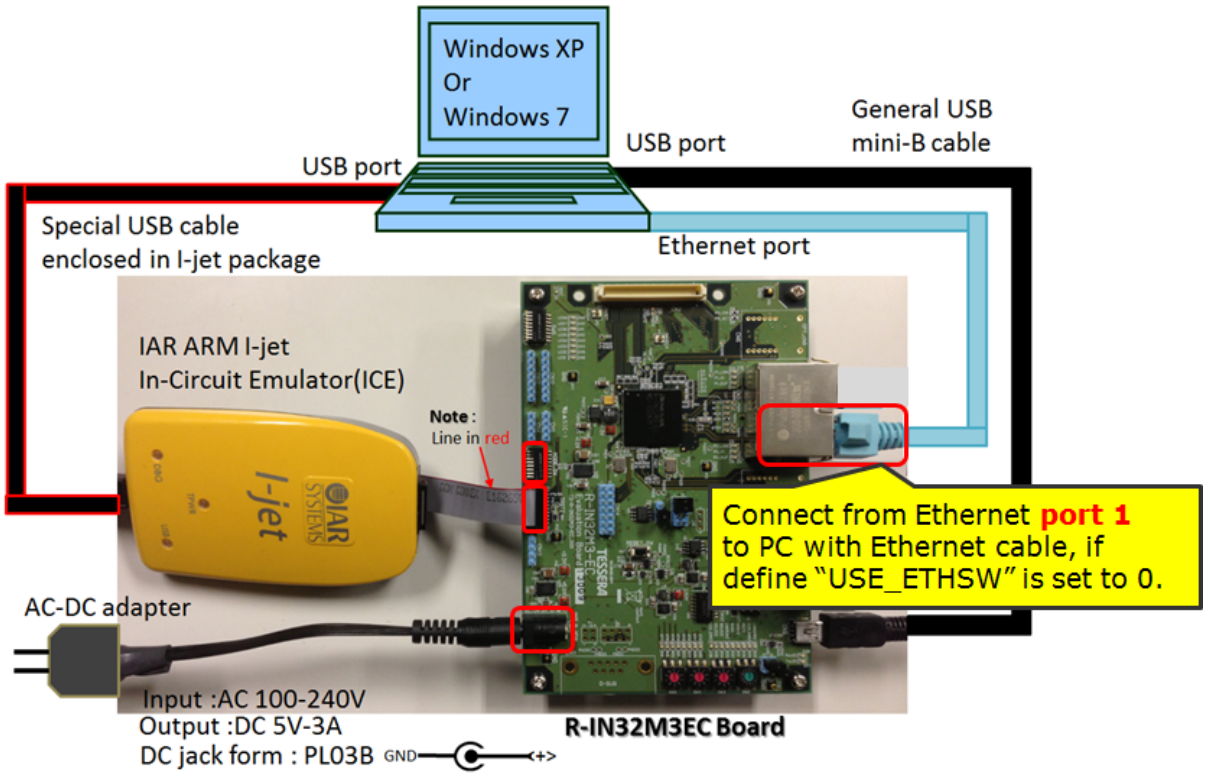


Fig. 7.1 Physical port connection for sample application

7.3 Board IP address setting

There are two options for setting the IP address. Either use a fixed IP address, or let the LAN network DHCP controller set it.

7.3.1 Setting for use a fixed IP address

Please set according to following procedure.

(1) Set DHCP_ENA to 0 in net_sample.c.

(2) Set desired server network address setting in net_cfg.c. Example is shown in Fig. 7.2.

```
/*****************************************
    Define Local IP Address
*****************************************/
T_NET_ADR gNET_ADR[] = {
    {
        0x0,                /* Reserved */
        0x0,                /* Reserved */
        0xC0A80164,         /* IP address (192.168.   1.100) */
        0xC0A80101,         /* Gateway       (192.168.   1.   1) */
        0xFFFFFF00,         /* Subnet mask (255.255.255.   0) */
    }
};
```

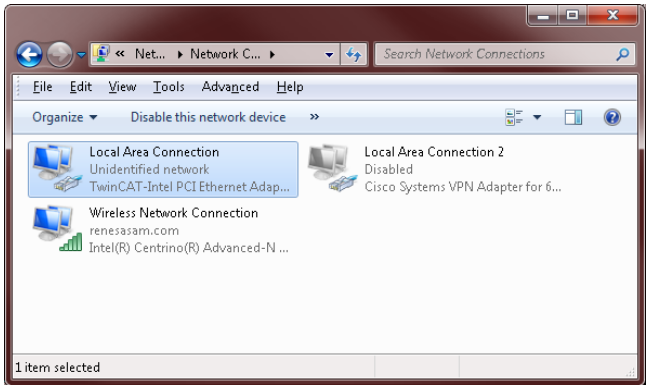
Fig. 7.2 The example setting of IP address (in case IP address is 192.168.1.100)

(3) Your PC's IP-address need to be in the same domain as the R-IN32M3 board. (Please also refer next page as detail procedure.)
In this example we will use:
Subnet mask: 255.255.255.0.
PC IP-address: 192.168.1.101.
This is so that server and client are in the same domain.

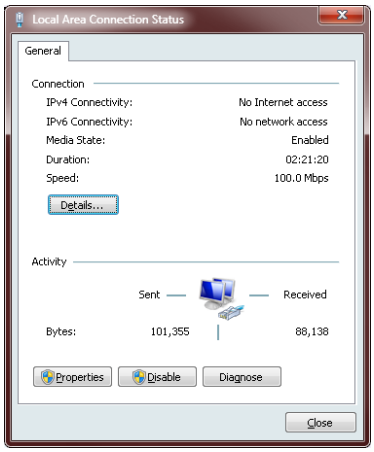
(4) Skip next section "7.3.2 Setting for use DHCP ".

cf. How to set the PC IP-address (not using DHCP)

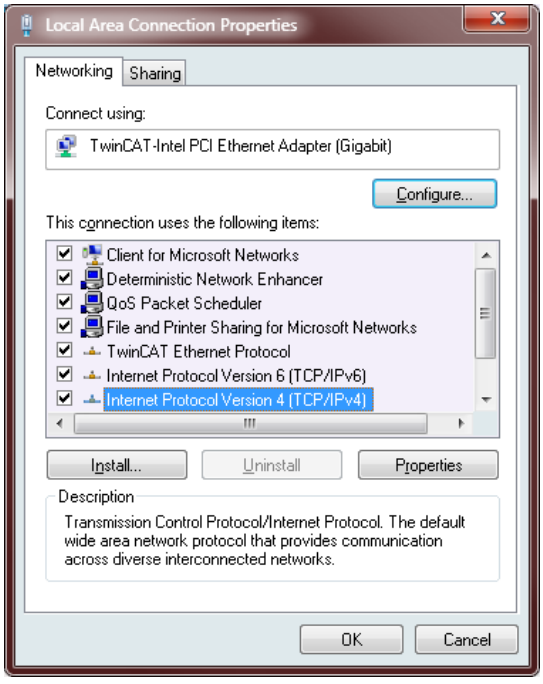
- Open the network connections list.
  In Windows7: Control panel->Network and Sharing Center->Change adapter settings.



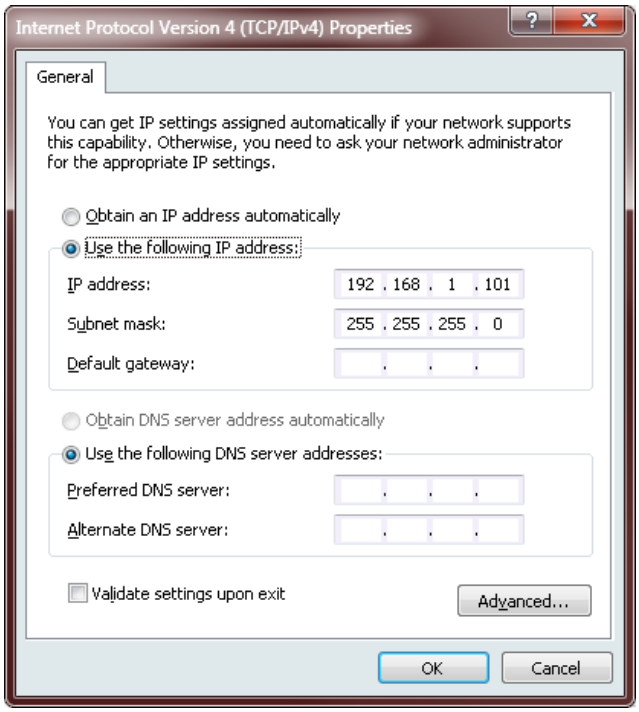
- Double-click (or right-click) on the Local Area Connection, then select "Properties".



- Select TCP/IPv4, and push the Properties button.



- Set IP-address to 192.168.1.101, and sub net mask to 255.255.255.0


Internet Protocol Version 4 (TCP/IPv4) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address: 192 . 168 . 1 . 101
Subnet mask: 255 . 255 . 255 . 0
Default gateway:
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server:
Alternate DNS server:
Validate settings upon exit
Advanced...
OK
Cancel

Done.

7.3.2 Setting for use DHCP function

When DHCP client is enabled, IP address is defined automatically by DHCP server. In this case, UDP socket for DHCP is also added automatically.

Please set according to following procedure.

(1) Set DHCP_ENA to 1 in net_sample.c.
(2) Connect the LAN server IP cable to port 1
(3) Connect the LAN server IP cable to the PC.

Note If user uses EWARM evaluation version which is size limited 32KB and set DHCP_ENA to 1, the sample project might not be able to compile because of size limitation.

7.4 Demonstration

7.4.1 Webserver

In this example we will use the IAR project “uNet3_sample”. The workbench file is in
..\r-in32m3_samplesoft\r-in32m3_samplesoft\Device\Renesas\RIN32M3\Source\Project\uNet3_sample
\IAR \main.eww

Please execute the following procedure.

1. Compile, download, and run application.
2. Open a web browser in PC (client),
3. Enter into the URL field http://192.168.1.100 (or http://192.168.1.100:80 , but socket is default 80 for http).

If the board is running the project above, you should see a webpage from the R-IN32M3 like Fig. 7.3 .
If you have problems getting or seeing anything in the browser, you may need to restart the code in IAR, and/or get rid of breakpoints that cause timeouts.

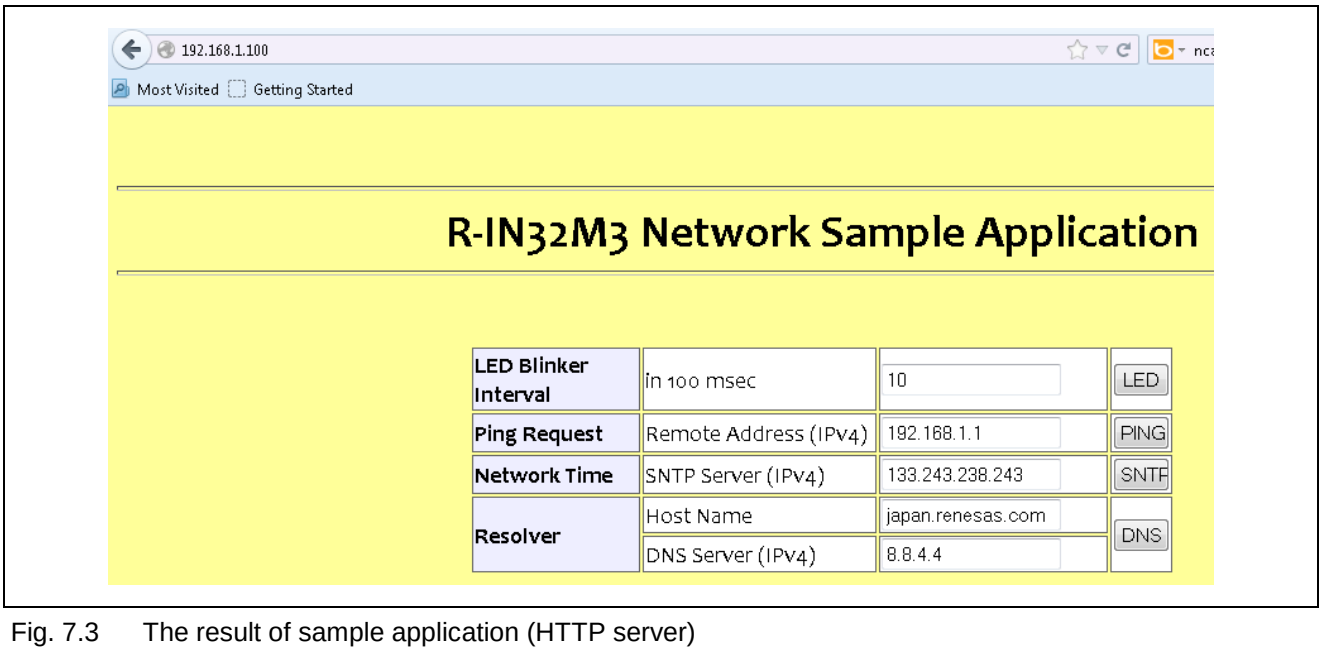


Fig. 7.3 The result of sample application (HTTP server)

8. Appendix

8.1 Packet format

(1) T_NODE

Information of communication endpoint

```
typedef struct t_node {
        UH      port;       /* Port number of socket */
        UB      ver;        /* IP version*/
                            /* Necessarily specify IP_VER4 */
        UB      num;        /* Device number*/
        UW      ipa;        /* IP address */
} T_NODE;
```

(2) T_NET_ADR

Information of network address

```
typedef struct t_net_adr {
        UB      ver;        /* IP- Version*/
                            /* Necessarily specify IP_VER4*/
        UB      mode;       /* Reserve*/
        UW      ipaddr;     /* IP Address*/
        UW      gateway;    /* Gateway*/
        UW      mask;       /* Subnet mask*/
} T_NET_ADR;
```

(3) T_NET_DEV

The information of the network device

```
typedef struct t_net_dev {
        UB          name[8];    /* Device name */
        UH          num;        /* Device number */
        UH          type;       /* Device type */
        UH          sts;        /*Reserve */
        UH          flg;        /* Reserve */
        FP          ini;        /* Pointer to dev_ini function*/
        FP          cls;        /*Pointer to dev_cls function*/
        FP          ctl;        /* Pointer to dev_ctl function*/
        FP          ref;        /*Pointer to dev_ref function*/
        FP          out;        /*Pointer to dev_snd function*/
        FP          cbk;        /*Pointer to dev_cbk function*/
        UW          *tag;       /*Reserve */
        union {                 /* MAC address */
          struct {
        UB          mac[6];
```

```
        }eth;
        } cfg;
        UH          hhdrsz;     /* Device header size */
        UH          hhdrofs;    /* Position of writing network buffer*/
} T_NET_DEV;
```

(4) T_NET_BUF

Information of network buffer<R>

```
typedef struct t_net_buf {
        UW          *next;      /* Reserve */
        ID          mpfid;      /* Memory pool ID */
        T_NET       *net;       /* Network interface */
        T_NET_DEV   *dev;       /* Network device */
        T_NET_SOC   *soc;       /* Socket*/
        ER          ercd;       /* Error code */
        UH          flg;        /* Protocol stack control flag*/
        UH          seq;        /* Fragment sequence */
        UH          dat_len;    /* Data size of packet */
        UH          hdr_len;    /* Header size of packet*/
        UB          *dat;       /* Indicate data position of packet (buf) */
        UB          *hdr;       /* Indicate header position of packet (buf) */
        UB          buf[];      /* Actual packet */
} T_NET_BUF ;
```

(5) T_HOST_ADDR

Information of host address

```
typedef struct t_host_addr {
        UW      ipaddr;     /* IP address*/
        UW      subnet;     /* Subnet mask */
        UW      gateway;    /* Gateway */
        UW      dhcp;       /* DHCPserver address */
        UW      dns[2];     /* DNS address */
        UW      lease;      /* Lease period of DHCP address */
        UW      t1;         /* Renewal period of DHCP address*/
        UW      t2;         /* Rebind period of DHCP address */
        UB      mac[6];     /* MAC address */
        UB      dev_num;    /* Device number */
        UH      socid;      /* UDP socket ID */
} T_HOST_ADDR ;
```

(6) T_FTP_SERVER

FTP server control information

```
typedef struct t_ftp_server {
    UB      dev_num;        /* Device number */
    UH      ctl_socid;      /* SocketID for command */
    UH      data_socid;     /* SocketID for data */
    UB      *fs_file;       /* Store buffer */
    UW      fs_maxsz;       /* Store buffer size */
} T_FTP_SERVER ;
```

(7) T_HTTP_FILE

HTTP Content Information

```
typedef struct t_http_file {
    const char      path[12];                   /* URL */
    const char      ctype[12];                  /* Content type*/
    const char      *file;                      /* Content */
    int             len;                        /* Content size*/
                                                /* HTTP callback function
    void(*cbk)(T_HTTP_SERVER *http);            or
                                                CGI handler */
} T_HTTP_FILE ;
```

(8) T_HTTP_SERVER

HTTP Server control information

```
typedef struct t_http_server {
    UW              sbufsz;         /* Transmission buffer size */
    UW              rbufsz;         /* Reception buffer size */
    UW              txlen;          /* Internal data*/
    UW              rxlen;          /* Internal data*/
    UW              rdlen;          /* Internal data*/
    UW              len;            /* Internal data*/
    UB              *rbuf;          /* Transmission buffer*/
    UB              *sbuf;          /* Reception buffer */
    UB              *req;           /* Internal data*/
    UH              Port;           /* Listerning port number*/
    UH              SocketID;       /* Socket ID */
T_HTTP_HEADER       hdr;            /* HTTP client request */
  UB                NetChannel;     /* Device number */
  UB                ver             /* IP version */
} T_HTTP_SERVER;
```

(9) T_RCV_PKT_INF

Reception packet information

```
typedef struct t_rcv_pkt_inf{
    UW      src_ipa;        /* Source IP address of packet*/
    UW      dst_ipa;        /* Destination IP address of packet*/
    UH      src_port;       /* Source port number of packet*/
    UH      dst_port;       /* Destination port number of packet*/
    UB      ttl;            /* IP header TTL of packet*/
    UB      tos;            /* IP header TOS of packet*/
    UB      ver;            /* IP header version of packet*/
    UB      num;            /* Reception device number of packet/
} T_RCV_PKT_INF;
```

(10) T_DHCP_CLIENT

DHCP Client information

```
typedef struct t_dhcp_client {
    T_DHCP_CTL  ctl         /* Internal data*/
    UW          ipaddr;     /* IP address*/
    UW          subnet;     /* Subnet mask */
    UW          gateway;    /* Gateway */
    UW          dhcp;       /* DHCPserver address */
    UW          dns[2];     /* DNS address */
    UW          lease;      /* Lease period of DHCP address */
    UW          t1;         /* Renewal period of DHCP address*/
    UW          t2;         /* Rebind period of DHCP address */
    UB          mac[6];     /* MAC address */
    UB          dev_num;    /* Device number */
    UB          state;      /* DHCP client status */
    UH          socid;      /* UDP socket ID */
    UB          arpchk      /* APR check */
} T_DHCP_CLIENT;
```

(11) T_PING_CLIENT

Ping Client Information

```
typedef struct   t_ping_client {
    ID      sid;            /* ICMP Socket ID */
    UW      ipa;            /* Destination IP Address */
    TMO     tmo;            /* Response Time out */
    UH      devnum;         /* Device number */
    UH      len;            /* Packet Size */
} T_PING_CLIENT;
```

(12) T_SNTP_CLIENT

SNTP Client Information

```
typedef struct   t_sntp_client {
        ID       sid;          /* UDP Socket ID */
        UW       ipa;          /* NTP server IP address */
        TMO      tmo;          /* Response Time out */
        UH       devnum;       /* Device numbr */
        UH       port;         /* NTP server port number */
        UB       ipv;          /* IP vrsion */
} T_SNTP_CLIENT;
```

8.2 Constant and Macro

(1) IP Address

ADDR_ANY	IP address 0
IP_VER4	IP version 4

(2) Port Number

PORT_ANY	Port number 0

(3) IP protocol

IP_PROTO_TCP	TCP protocol
IP_PROTO_UDP	UDP protocol
IP_PROTO_ICMP	ICMP protocol

(4) Network interface control

NET_IP4_CFG	Configure and verify IP Address, Subnet mask
NET_IP4_TTL	Configure and vefiry TTL
NET_BCAST_RCV	Configure and verify reception of broadcast
NET_MCAST_JOIN	Join in multicast group
NET_MCAST_DROP	Drop from multicast Group
NET_MCAST_TTL	Configure TTL used in multicast transmission

(5) Parameter of socket

SOC_IP_TTL	Configure and verify TTL of Socket
SOC_IP_TOS	Configure and verify TOS of Socket
SOC_TMO_SND	Configure and verify blocking time-out of snd_soc
SOC_TMO_RCV	Configure and verify blocking time-out of rcv_soc
SOC_TMO_CON	Configure and verify blocking time-out of con_soc
SOC_TMO_CLS	Configure and verify blocking time-out of cls_soc
SOC_IP_LOCAL	Get port number and IP address of local host
SOC_IP_REMOTE	Get port number and IP address of remote host
SOC_CBK_HND	Register callback function
SOC_CBK_FLG	Specify callback event
SOC_RCV_PKT_INF	Get information of reception packet

(6) Connection mode of socket

SOC_CLI	Connect to remote host (active connection)
SOC_SER	Wait for connection (passive connection)

(7) Termination mode of socket

SOC_TCP_CLS	Disconnect socket. (Terminate connection)
SOC_TCP_SHT	Disable only the transmission process. Reception is possible

(8) Interruption mode of socket

SOC_ABT_CON	Abort con_soc()
SOC_ABT_CLS	Abort cls_soc()
SOC_ABT_SND	Abort snd_soc()
SOC_ABT_RCV	Abort rcv_soc()
SOC_ABT_ALL	Abort all the processes of socket

(9) Callback Event

EV_SOC_CON	Enable con_soc() to be non-blocking mode
EV_SOC_CLS	Enable cls_soc() to be non-blocking mode
EV_SOC_SND	Enable snd_soc() to be non-blocking mode
EV_SOC_RCV	Enable rcv_soc() to be non-blocking mode

8.3 Error Code List

E_NOSPT	-9	Unsupported function
E_PAR	-17	Parameter error
E_ID	-18	Illegal ID number
E_NOMEM	-33	Insufficient memory
E_OBJ	-41	Object status error
E_NOEXS	-42	Uncreated object
E_QOVR	-43	Queuing overflow
E_RLWAI	-49	Forced cancellation of wait state
E_TMOUT	-50	Polling failure or time-out
E_CLS	-52	Change status of waiting object
E_WBLK	-57	Non-blocking acceptance
E_BOVR	-58	Buffer overflow

8.4 API List

API Name	
A) Network Interface	
net_ini	Initialize TCP / IP protocol stack
net_cfg	Configure parameters of network interface
net_ref	Refer parameters of network interface
net_acd	Detection IP Address Confliction
B) Network Device Control	
net_dev_ini	Initialize network device
net_dev_cls	Release Network Device
net_dev_ctl	Control network device
net_dev_sts	Get status of network device
C) Socket	
cre_soc	Create socket (Standard version only)
del_soc	Delete a socket (Standard version only)
con_soc	Socket connection
cls_soc	Socket interruption
snd_soc	Send data
rcv_soc	Receive data
cfg_soc	Configure parameter of socket
ref_soc	Refer parameter of socket
abt_soc	Abort process of socket
D) Network Application	
dhcp_client	Start DHCP Client
ftp_server	Start FTP Server
http_server	Start HTTP server
CgiGetParam	Analyze CGI argument
HttpSendText	Send text content
HttpSendFile	Send Attached File
HttpSendImage	Send Image Content
dns_get_ipaddr	Get IP address from host name
dns_get_name	Get host name from IP address
dhcp_bind	Get DHCP Lease Information
dhcp_renew	Renewal DHCP lease information
dhcp_reboot	Reboot DHCP client
dhcp_release	Release DHCP lease information
dhcp_inform	Get DHCP option
ping_client	ICMP Echo request and response
sntp_client	Get NTP time
E) Others	
ip_aton	Convert IPv4 address string in dot notation to 32-bit value
ip_ntoa	Convert 32-bit value IPv4 address to IPv4 address string in dot notation
ip_byte2n	Convert IPv4 address array to 32 bit value
ip_n2byte	Convert 32-bit value IPv4 addresse to array
htons	Convert 16-bit value to network byte order

ntohs	Convert 16-bit value to host byte order
htonl	Convert 32-bit value to network byte order
ntohl	Convert 32- bit value to host byte order

8.5 Resource list <R>

8.5.1 Kernel objects

(1) Kernel object used by Ethernet device driver

Object	Object ID	Description
Task	ID_TASK_ETH_SND	Ether driver send task (stack size: 1024Byte)
Task	ID_TASK_ETH_RCV	Ether driver receive task (stack size: 1024Byte)
Task	ID_TASK_PHY0_LINK	PHY driver control task (stack size: 512Byte)
Task	ID_TASK_PHY1_LINK	PHY driver control task (stack size: 512Byte)
Event flag	ID_FLG_ETH_RX_MAC	Ether driver event flag
Event flag	ID_FLG_ETH_TX_MAC	Ether driver event flag
Event flag	ID_FLG_PHY_STS	Ether driver event flag
Event flag	ID_FLG_SYSTEM	Ether driver event flag
Mail box	ID_MBX_ETH_SND	Ether driver mail box
Mail box	ID_MBX_ETH_MEMPOL	Ether driver mail box

(2) Kernel object used by TCP/IP protocol stack (μ Net3 compatible)

Object	Object ID	Description
Task	ID_TASK_TCP_TIM	TCP/IP stack time management task for R-IN32M3
Semaphore	ID_SEM_TCP	Semaphore to control protocol stack resource.

(3) Kernel object used by TCP/IP protocol stack (BSD compatible)

Object	Object ID	Description
Task	ID TSK_BSD_API	BSD Wrapper task
Task	ID_LO_IF_TSK	Loop back device task
Mail box	ID MBX_BSD_REQ	BSD Wrapper communication between task
Mail box	ID_LO_IF_MBX	Communication between device task

Note Kernel objects used by TCP/IP protocol stack (uNet3 compatible) are also used added to above.

(4) Kernel object used by memory management

Object	Object ID	Description
Mail box	ID_MBX_ETH_MEMPOL	Memory management

8.5.2 Hardware ISR

Table.8.1 Hardware ISR used by TCP/IP stack for R-IN32M3

Hardware ISR reason	Operation	Description
PHY0_IRQn	set_flg()	PHY driver
PHY1_IRQn	set_flg()	PHY driver
ETHTXDMA_IRQn	set_flg()	Ethernet driver send operation
ETHTXDERR_IRQn	set_flg()	Ethernet driver send operation
ETHTX_IRQn	set_flg()	Ethernet driver send operation
ETHTXFIFO_IRQn	set_flg()	Ethernet driver send operation
ETHTXFIFOERR_IRQn	set_flg()	Ethernet driver send operation
ETHRXDMA_IRQn	set_flg()	Ethernet driver receive operation
ETHRXFIFO_IRQn,	set_flg()	Ethernet driver receive operation
ETHRXDERR_IRQn	set_flg()	Ethernet driver receive operation
ETHRXERR_IRQn	set_flg()	Ethernet driver receive operation

REVISION HISTORY	R-IN32M3 Series User's Manual: TCP/IP stack

Rev.	Date	Description	
		Page	Summary
1.00	Jul 26, 2013	-	First edition issued
2.00	Oct 4, 2013	-	Typos are fixed all over this document.
		2	*Table 1.2Development tools* EWARM version is fixed.
		9	*Fig. 2.2Block diagram of network system* Typos in figure fixes.
		10	*Table 2.1OS Kernel objects which are used in TCP/IP stack for R-IN32M3* Delete"ID_ NET_MAIN_TSK" as not used.
		11	*Table 2.2Hardware ISR which are used in TCP/IP stack for R-IN32M3* New created
		23	*3.2Network device driver* Sentences fixes.
		96	*7.3Behavior confirmation* Add procedure.
2.01	Apr 18, 2014	94-98	Add some detail descriptions in ***7.Tutorial by sample application***
3.00	Feb 28, 2015	1	Modify Table 1.1The difference between evaluation edition and commercial edition
		11	Modify 2.3Directory and file organization
		32	Modify 3.2.4T_NET_DEV information registration example
		35	Modify 3.3.1Network buffer
		39	Add 3.5Ethernet device driver
		54	Add 3.6PHY driver
		87	Add5.5Socket API (BSD compatible)
		159	Modify (4)T_NET_BUF of 8.1Packet format
		167	Add 8.5Resource list

[Memo]

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